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Nuclear and radiochemistry curricula in the European universities

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EXECUTIVE SUMMARY

Deliverable 1.1. covers a summary report on the nuclear and radiochemistry curricula in European universities. Survey of the European universities giving education in nuclear and radiochemistry was executed, mainly by internet survey and sending a questionnaire to the appropriate departments. Detailed information on various curricula in NRC was collected and analyzed: educational programs at different levels (BSc, MSc, PhD) were compared by their extent, contents and focus on education. In the main text of the report education is first discussed in general level and subsequently described in each listed country. Contact information to the universities/departments included in the survey is attached as an Appendix 1.

This deliverable contributes to the following Work-Packages and Tasks:

WP 1

Task 1.1 Task 1.2 Task 1.3 Task 1.4 Task 1.5 Task 1.6

WP 2

Task 2.1 Task 2.2 Task 2.3

WP 3

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WP 5

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WP 6

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1 INTRODUCTION

Cooperation in education In Nuclear Chemistry (CINCH) -project was started in February, 2010, having a main goal in coordination of the current diverse education and training schemes in nuclear chemistry: a long term sustainable strategy for the nuclear chemistry education would secure future source of highly qualified professionals.

The first objective of the project was to identify the current and potential level of education in nuclear and radiochemistry within Europe: collected data would provide information on European universities giving education in nuclear and radiochemistry, create a ground for a database of existing practical works and educational material under nuclear chemistry, and eventually help us to define optimum curricula leading to different levels of nuclear chemical education, for future “European Master in Nuclear Chemistry”. Results from this survey are discussed in this report.

Information was collected during the year 2010 mainly by internet survey and sending a questionnaire to the nuclear and radiochemistry departments throughout Europe. Education at BSc, MSc or PhD –level was considered. Nuclear engineering or related programs were included only if they contain substantially courses on nuclear and/or radiochemistry (abbreviated to NRC). Credit values for the programs/courses were defined by the ECTS (European Credit Transfer and Accumulation System) grading system, i.e. 1 credit corresponds 27 hours of work. Eventually 22 countries and 69 universities were included in the evaluation. The overall percentage of the returned questionnaires was 60%; corresponding value among the 45 universities having a more extensive curriculum in nuclear and radiochemistry was 70%, respectively.

Universities were listed and categorized in each country by the extent of education, i.e. nuclear and radiochemistry is taught as an educational program/specialization or as separate courses under other educational programs. Subsequently, the universities were categorized by their focus on education. Various curricula in NRC were compared by the specialization field: the extent of education was evaluated both by the versatility of the curricula as well as number of students attending/graduating. The detailed analysis on the curricula was mainly based on the information that was given in 42 returned questionnaires.

In the main text of the report education on nuclear and radiochemistry is first discussed in general level and subsequently described in each listed country. Contact information to the universities/departments included in the survey is attached as an Appendix 1. The report was sent for review to all of the listed contact persons and revised by the comments received thereafter in 2011/2012.

2 UNIVERSITIES GIVING EDUCATION IN NUCLEAR AND RADIOCHEMISTRY

The aim of this study was to survey current university curricula in nuclear and radiochemistry (NRC) at BSc, MSc or PhD-level. A significant part of the nuclear related education in Europe, i.e. nuclear engineering and technology programs, is tailored to the needs of nuclear power industry and has less nuclear and radiochemistry involved. On the other hand, many universities/institutions have high level of nuclear and radiochemistry research and offer possibility to do PhD-work in various related fields but have no education at lower levels (or education for BSc/MSc students is only given in basic level). Furthermore, closer collaboration between universities and industry/research units brings education and training closer to each other, which complicates evaluation of the academic programs. 22 countries and 69 universities were eventually included in this survey as depicted in Fig. 2.1.

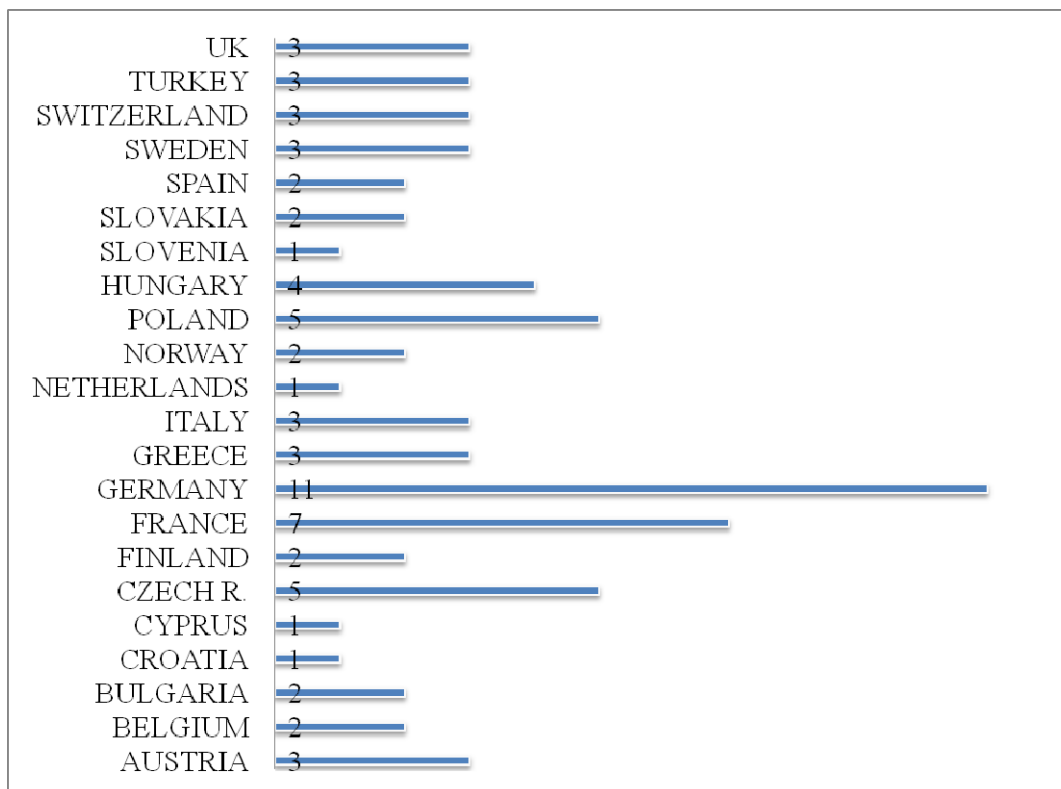


Figure 2.1: Number of universities giving education in NRC in each listed European country.

The universities are categorized by the extent (and level) of education in each listed country in the Appendix 1. The findings are summarized in Fig. 2.2., i.e. minority of the universities has specialized education (BSc/MSc program or specialization) in NRC; more typical is to teach individual courses under various educational programs. Details of the various curricula will be discussed later on in this report.

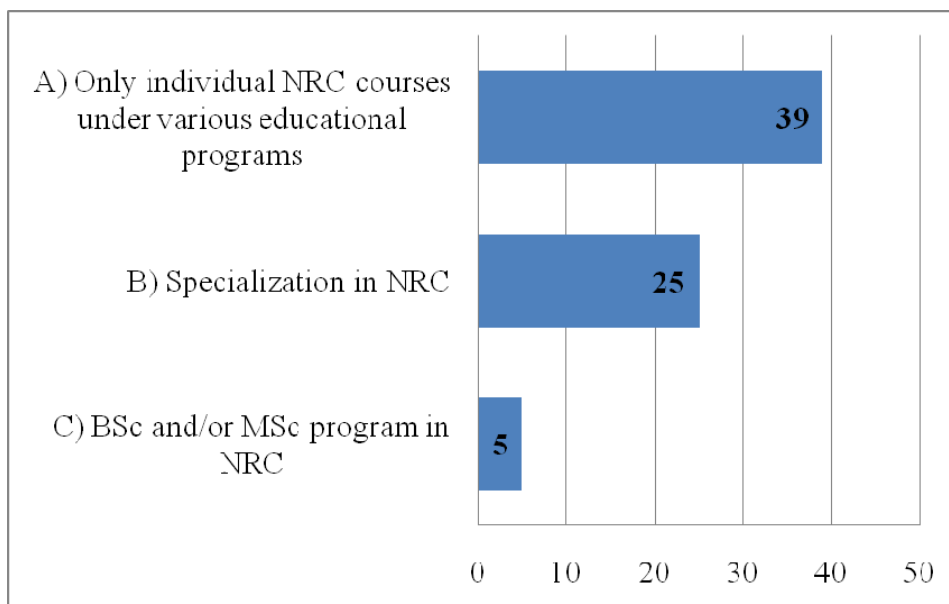


Figure 2.2: Categorization of the universities by the extent of education at BSc/MSc level. Blue bars represent total number of universities under each category. Category B includes universities offering NRC as a specialization, i.e. as a major subject or as a course module plus a possibility to do a diploma work.

A second classification is based on the area on which the education is focused. Typically the focus is related to the research interests in the department. Thus, in a large number of the universities a single focus on education cannot be stated as both general and applied NRC (such as environmental radiochemistry, radiopharmaceutical chemistry etc.) are included in the education. Alternatively, the BSc/MSc curriculum contains only courses on general nuclear and radiochemistry. These universities are listed in Table 2.1. Environmental radiochemistry and radioecology is the largest single area on which the education is focused. Other large fields are radiopharmaceutical chemistry and nuclear energy and materials (including nuclear waste and fuel cycle chemistry); some smaller areas are e.g. analytical radiochemistry. Universities are categorized under these educational focuses in Table 2.2.

Table 2.1: Universities having education in general and applied nuclear and/or radiochemistry

UNIVERSITY
Both general and applied nuclear and/or radiochemistry
XIOS HOGESCHOOL LIMBURG, Belgium
SOFIA UNIVERSITY, Bulgaria
CZECH TECHNICAL UNIVERSITY IN PRAGUE, Czech Republic
UNIVERSITY OF HELSINKI, Finland
RUPRECHT-KARL UNIVERSITY OF HEIDELBERG in collaboration with Karlsruhe Institute of Technology, Germany
DRESDEN UNIVERSITY OF TECHNOLOGY in collaboration with Forschungszentrum Dresden-Rossendorf, Germany
UNIVERSITY OF KÖLN in collaboration with FZ Jülich, Germany
FH AACHEN-UNIVERSITY OF APPLIED SCIENCES, Germany
KARLSRUHE INSTITUTE OF TECHNOLOGY, Germany
JOHANNES GUTENBERG UNIVERSITY, Germany
UNIVERSITY OF OSLO, Norway
INSTITUTE OF NUCLEAR CHEMISTRY AND TECHNOLOGY, Poland
EÖTVÖS LORÁND UNIVERSITY, Republic of Hungary
CHALMERS UNIVERSITY OF TECHNOLOGY, Sweden

UNIVERSITY OF BERN in collaboration with Paul Scherrer Institute, Switzerland
UNIVERSITY OF MANCHESTER, UK

Only general nuclear and/or radiochemistry

VIENNA UNIVERSITY OF TECHNOLOGY, Austria
UNIVERSITY OF INNSBRUCK, Austria
UNIVERSITY OF ZAGREB, Croatia
MASARYK UNIVERSITY, Czech Republic
UNIVERSITY OF NICE-SOPHIA ANTIPOLIS, France
FREIE UNIVERSITÄT BERLIN, Germany
ARISTOTLE UNIVERSITY, Greece
UNIVERSITY OF PATRAS, Greece
NATIONAL TECHNICAL UNIVERSITY OF ATHENS, Greece
UNIVERSITY OF PAVIA, Italy
UNIVERSITY OF NAPOLI, Italy
NICOLAUS COPERNICUS UNIVERSITY, Poland
BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS, Republic of Hungary
UNIVERSITY OF BARCELONA, Spain
UNIVERSITY OF GRANADA, Spain
UNIVERSITY OF ZURICH, Switzerland
EGE UNIVERSITY, Turkey
MIDDLE EAST TECHNICAL UNIVERSITY, Turkey
BILKENT UNIVERSITY, Turkey

Table 2.2: Universities with more specified focus of education¹ in NRC

FOCUS OF EDUCATION	UNIVERSITY
Environmental radiochemistry and radioecology	UNIVERSITY OF VIENNA, Austria
	PLOVDIV UNIVERSITY, Bulgaria
	UNIVERSITY OF CYPRUS, Cyprus
	LEIBNIZ UNIVERSITY OF HANNOVER, Germany
	NORWEGIAN UNIVERSITY OF LIFE SCIENCES, Norway
	UNIVERSITY OF GDANSK, Poland
	UNIVERSITY OF PANNONIA, Republic of Hungary
	DEBRECEN UNIVERSITY, Republic of Hungary
	JOŽEF STEFAN INTERNATIONAL POSTGRADUATE SCHOOL, Republic of Slovenia
	COMENIUS UNIVERSITY, Slovakia
	TECHNICAL UNIVERSITY OF ZVOLEN, Slovakia
	UNIVERSITY OF LOUGHBOROUGH, UK
	Radiopharmaceutical chemistry
UNIVERSITY OF TURKU, Finland	
MUNCHEN UNIVERSITY OF TECHNOLOGY, Germany	
UNIVERSITY OF MILAN, Italy	
UNIVERSITY OF WARSAW, Poland	
UPPSALA UNIVERSITY, Sweden	
TECHNICAL UNIVERSITY OF ZURICH, Switzerland	
KING'S COLLEGE LONDON, UK	

Nuclear energy and materials²

PARIS SUD UNIVERSITY XI, France
CHIMIE PARISTECH (École nationale supérieure de chimie de Paris), France
UNIVERSITY MONTPELLIER 2, France
l'Ecole Nationale Supérieure de Chimie de Montpellier, France
École des Mines of Nantes (SUBATECH), France
GRENOBLE INP Phelma in collaboration with EDF and CEA - INSTN, France
TU CLAUSTHAL, Germany
HOCHSCHULE ZITTAU/GÖRLIZ -University of Applied Sciences, Germany
DELFT UNIVERSITY OF TECHNOLOGY, The Netherlands
KTH ROYAL INSTITUTE OF TECHNOLOGY, Sweden

Analytical radiochemistry

GHENT UNIVERSITY, Belgium
INSTITUTE OF CHEMICAL TECHNOLOGY PRAGUE, Czech Republic
MARIA CURIE SKLODOWSKA UNIVERSITY, Poland

Miscellaneous topics

Military nuclear chemistry UNIVERSITY OF DEFENCE, Czech Republic

¹ A specific focus is stated in the questionnaire and/or education in the specific field is given in addition to basic NRC courses.

² Includes e.g. nuclear waste management and fuel cycle chemistry.

3 NUCLEAR AND RADIOCHEMISTRY EDUCATION AT BSC AND MSC LEVEL

In 83 % of the universities responded to the questionnaire NRC is taught at MSc level or both at MSc and BSc levels; 17 % of universities have education only at BSc (or lower) level.

A major part of the NRC education, especially at BSc level, is given as individual courses under various educational programs such as for students in chemistry (or chemical engineering), physics, biochemistry, pharmacy (nuclear medicine), as well as in geology and environmental sciences. These courses are categorized by their most popular topics in Fig. 3.1.

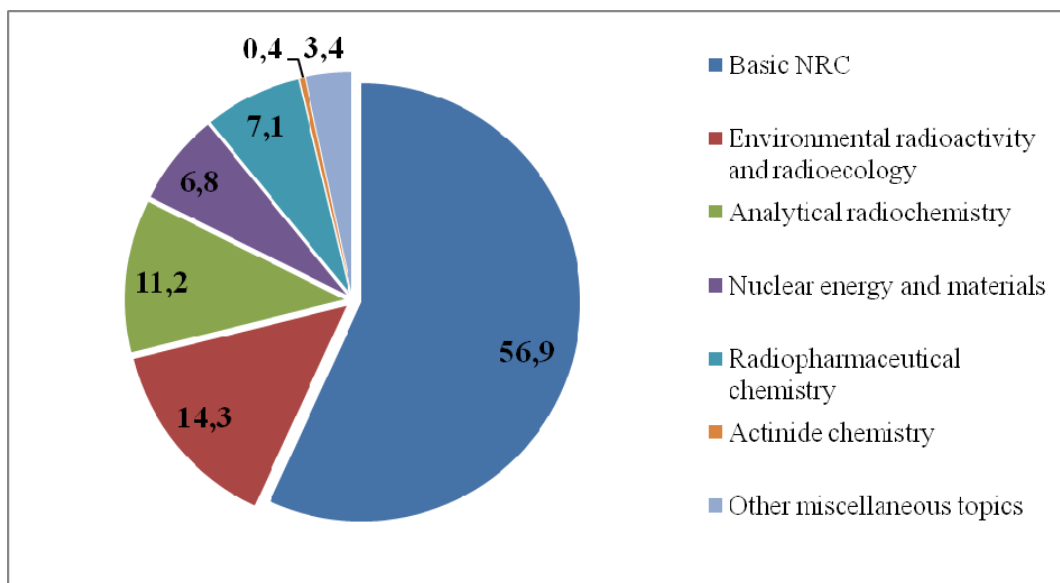


Figure 3.1: Major topics of individual NRC courses taught under various educational programs; presented as percentage of the total amount of credit units. (The diagram is based on the available information in the internet as well as in returned questionnaires.)

BSc and MSc programs (degrees) in general and applied NRC are rather limited, 10 in 5 different universities. However, in a number of universities nuclear and/or radiochemistry is included as a specialization, i.e. a major subject, in MSc studies of Chemistry or other related programs. The interpretation of specialization varies a lot depending on the educational system: there are MSc programs with 60, 90 or 120 credit units; under a complete MSc program (120 ECTS) requirements for studies in NRC may vary from 47 to 113 credit units. The extent and contents of specialization may also depend on background education, i.e. the MSc program is aimed at students with certain lower level degree in nuclear and/or radiochemistry. Furthermore, research training and diploma work have typically a significant role in specialization. Thus, course modules (typically in German universities) were also considered as a specialization when there is a possibility to do a diploma (thesis) work in the same field.

Altogether, there are 44 educational programs (degree and/or specialization) related to NRC in 30 different universities. Diversity of these educational programs is depicted in Table 3.1. Furthermore, various fields of specializations are summarized in Figure 3.2.

Table 3.1: Examples of NRC related BSc/MSc degrees and specializations in various universities

Degree ¹ /specialization	University	Contents of specialization ²
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		Courses/ seminars	Final exam(s)	Research training/ projects	Thesis work	Total ECTS
EurMSc in Radioecology	Norwegian University of Life Sciences	30	(3)	30	60	120
MSc in Nuclear Chemistry (60 ECTS)	University of Sofia	30	(8)	15	15	60
MSc in Radiochemistry and radioecology (90 ECTS)	University of Sofia	50	(10)	20	20	90
MSc in Radiopharmaceutics & PET Radiochemistry (90 ECTS)	King's College London					
BSc in Nuclear Chemistry (240 ECTS)	University of Sofia	93	-	4	10	107
BSc in Nuclear Chemical engineering (180 ECTS)	Czech Technical University in Prague	19-22	-	1	15	35-38
MSc in Nuclear Chemical engineering (120/180 ECTS): <i>Applied Nuclear chemistry</i>	Czech Technical University in Prague	min 53	-	25	35	min 113
MSc in Chemistry: <i>Radiochemistry</i>	University of Helsinki	33-34	7	3	40	83-84
MSc in Chemistry: <i>Nuclear Chemistry</i>	University of Oslo	20-40			60	80-100
MSc in Chemistry: <i>Nuclear chemistry and radioecology</i>	Comenius University	57	-	14	29	100
MSc in Nuclear engineering: <i>Nuclear Chemistry</i>	Chalmers University of Technology	45	-	-	30	75
MSc in Chemical engineering: <i>Radiochemical technology</i>	University of Pannonia	26	-	-	30	56
MSc in Environmental engineering: <i>Radioecology</i>	University of Pannonia	17	-	-	30	47
MSc in Nuclear Energy: <i>Fuel cycle engineering / radiochemistry</i>	French consortium					
MSc in Advanced Nuclear Waste Management	French consortium					

¹ 120 ECTS unless stated otherwise

² Curriculum in NRC

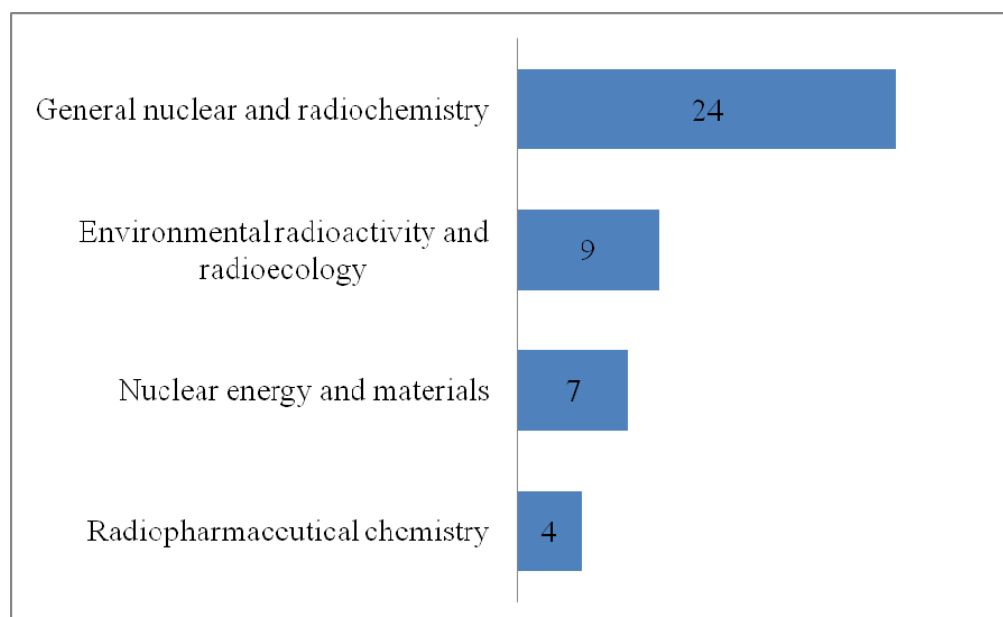


Figure 3.2: Current BSc/MSc degrees and specializations categorized in general and applied NRC. Blue bars represent number of educational programs under each specified field.

3.1 Nuclear and radiochemistry curricula at BSc level

There are only two programs in NRC at BSc level. The University of Sofia in Bulgaria offers an extensive BSc degree in Nuclear Chemistry with 240 ECTS. First 10 students graduated from this program in 2010. Details of the curriculum are described in Table 3.1.1. The Czech Technical University in Prague (CTU) awards a BSc degree in Nuclear Chemical engineering. It is a three-year program with 180 ECTS. Average 6 students are graduating from this program every year. In addition, the University of Pannonia in Hungary has an engineering program BSc in Environmental engineering (210 ECTS). Average 8 students per year are awarded this degree with a specialization in radioecology. Nuclear chemistry related course supply for these programs is described in Table 3.1.2. The diploma work can be either literature survey (not in Pannonia) or combined with experimental work.

In German universities, University of Köln and University of Heidelberg a course module (11-15 ECTS, including research training) plus a diploma work (14 ECTS) in nuclear chemistry can be taken under the studies for BSc in Chemistry (180 ECTS); BSc program in Applied Chemistry (180 ECTS) in the FH Aachen University of Applied Sciences includes 10-40 ECTS nuclear and radiochemistry. Number of students attending these BSc courses is in the level of 10-25. The University of Loughborough in UK also offers undergraduate degrees (BSc 3 years, MChem 4 years) in Chemical Sciences with possibility to take a course module (20 ECTS) and do a thesis work (60 ECTS) in radiochemistry. In addition, the XIOS Hogeschool Limburg (Belgium) has an academic BSc program in Nuclear Engineering (180 ECTS) with specializations in environmental technology–radiochemistry and medical nuclear technology.

Table 3.1.1: Selected curricula for nuclear and radiochemistry at BSc level

Degree/specialization (University)	Courses	Final exam(s)	Research training	Diploma work	Total ECTS NRC(Total)
BSc in Nuclear Chemistry (University of Sofia)	93	(40)	4	10	107 (240)
BSc in Nuclear Chemical engineering (CTU)	19-22	-	1	15	35-38 (180)
BSc in Environmental engineering, specialization radioecology (University of Pannonia)	21	-	8	10	39 (210)
BSc in chemistry, module nuclear chemistry (University of Heidelberg)	12	-	3	12	27 (180)

Table 3.1.2: NRC related courses under certain BSc degrees/specializations in nuclear and radiochemistry

Degree	Course title	Credits	Type ¹
BSc in Nuclear Chemistry (University of Sofia)			
	Atomic and nuclear physics	9	L, E
	Nuclear chemistry and radiochemistry I-II	7	L, P
	Measurement of the ionization radiation	6	L, P
	Radiation protection	4	L, S
	Operation and decommissioning of nuclear power plants	6	L, P
	Radioanalytical chemistry	6	L, P
	Chemistry of the nuclear fuel cycle and of nuclear reactors	8	L, P
	Water treatment and water purification in the nuclear energetic	4	L, P
	Radioecology	4	L, P
	Production of radioactive isotopes and labeled compounds	5	L, P
	Radioactive wastes	5	L, E
	Nuclear safety. Risk analysis and risk informed decision making	3	L, S

	Fundamentals of radiobiology	4	L, P
<i>elective</i>	Hot atom chemistry	4	L, P
	Radioisotope dating	4	L, P
	Radionuclide methods in medicine	4	L, P
	Materials for the nuclear energetic	4	L, E
	Application of radionuclides	4	L, P
<hr/>			
BSc in Nuclear Chemical engineering (CTU)			
	Basic nuclear chemistry I	4	L, E
	Basic nuclear chemistry II	5	L, E
	Detection and dosimetry of IR	4	L
	Basics of nuclear physics	6	L, E
<i>elective</i>	Nuclear Power Plants Design and Operation	3	L, S
<hr/>			
BSc in Environmental engineering, specialization radioecology (University of Pannonia)			
	Basics of Radiation	1	L
	Radioecology	2	L
	Nuclear Energetic	2	L
	Dosimetry and Radiation Protection	2	L
	Nuclear emergency management, radioactive waste management	2	L
	Nuclear Metrology	2	L
	Uses of radioisotopes	2	L
	Lessons from the nuclear and radiation accidents	2	L
	Radiations and radionuclides in the nature	3	L
	Radioecology and Nuclear Metrology	6	P
<i>elective</i>	Nuclear Energetic	2	L
	Natural and artificial radiations	2	L
<hr/>			
BSc in Chemistry, module nuclear chemistry (University of Heidelberg)			
	Basic Radiochemistry I	6	L, E
	Basic Radiochemistry II	9	L, E, P

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

3.2 Curricula for MSc specializations in Nuclear and Radiochemistry

3.2.1 General nuclear and radiochemistry

Universities offering general nuclear and/or radiochemistry as an MSc program or a specialization are listed in Table 3.2.1.1. In this context general NRC means that the program is not specified under certain field, but the curricula cover both basic and applied NRC.

In the University of Sofia the MSc in Nuclear Chemistry (60 ECTS) is a new program (from 2010) aimed at students with the BSc degree in nuclear chemistry. At the Czech Technical University in Prague (CTU), students can take the degree MSc in Nuclear chemical engineering either as a 2 year (120 ECTS) or a 3 year (180 ECTS) program depending on the background education in nuclear and radiochemistry. Furthermore, specialization can be chosen from three fields of which Applied nuclear chemistry is discussed in this paragraph. Average 3 students are graduated with this degree annually.

Specialization in general nuclear and radiochemistry is also possible under certain MSc programs in chemistry or related fields. Majority of these programs are 2 year programs with 120 ECTS, however, the proportion of NRC included in the specialization varies to some extent. At the Chalmers University of Technology (Gothenburg, Sweden) nuclear chemistry major (75 or 45 ECTS) can be taken under the degrees MSc in Nuclear engineering and MSc in Chemistry and biosciences; approximately 20 students choose annually to study each of these specializations. In

the University of Oslo (Norway) chemistry students can specialize in nuclear chemistry (80-100 ECTS), however, the amount of students has been extremely low, average 1 graduate per year. Nuclear chemistry education of the Charles University in Prague is organised in collaboration with the CTU, curricula is mostly related to biomedical applications and will therefore be discussed in detail in paragraph 3.2.3. In the University of Helsinki in Finland specialization in radiochemistry (83-84 ECTS) can be taken under the degree MSc in Chemistry. Average 8 students are attending and 4 graduating from this program every year. In the Norwegian University of Life Sciences average 5 chemistry students are graduated annually with the specialization in general radiochemistry (90 ECTS).

In addition, in some universities general nuclear and radiochemistry can be taken as a course module and a diploma work can be done under related fields for MSc in Chemistry. These universities are e.g. University of Heidelberg (10 ECTS plus 30 ECTS for diploma work), University of Köln (13 ECTS plus 30 ECTS for diploma work) and Freie Universität Berlin (13 ECTS plus a diploma work) in Germany. In the University of Gdansk (Poland) the specialization in nuclear and radiochemistry includes total 23 ECTS of courses, research training and seminars and 30 ECTS for the diploma work.

Table 3.2.1.1: Universities offering an MSc degree or specialization¹ in general NRC

University	Degree/specialization	Credit values
UNIVERSITY OF SOFIA	MSc in Nuclear Chemistry	60 ECTS ²
CZECH TECHNICAL UNIVERSITY IN PRAGUE	MSc in Nuclear Chemical engineering * <i>applied nuclear chemistry</i>	120 or 180 ECTS ³ 110/144
CHALMERS UNIVERSITY OF TECHNOLOGY	MSc in Nuclear engineering * <i>nuclear chemistry</i>	120 ECTS 75
	MSc in Chemistry and biosciences * <i>nuclear chemistry</i>	120 ECTS 45
UNIVERSITY OF OSLO	MSc in Chemistry * <i>nuclear chemistry</i>	120 ECTS 80-100
CHARLES UNIVERSITY	* <i>nuclear chemistry</i>	100
UNIVERSITY OF HELSINKI	MSc in Chemistry * <i>radiochemistry</i>	120 ECTS 83-84
NORWEGIAN UNIVERSITY OF LIFE SCIENCES	* <i>radiochemistry</i>	90

¹ ≥ 45 ECTS of NRC included in the curriculum

² For students having BSc degree (240 ECTS) in Nuclear Chemistry

³ 120 ECTS for students having BSc degree in Nuclear Chemical engineering; for others 180 ECTS

Contents of the selected curricula in general nuclear and radiochemistry are described in Tables 3.2.1.2-3. In the University Sofia the course supply is rather specified as the students have basic NRC already at BSc level. The Czech Technical University in Prague has an extensive curriculum in NRC and a broad selection of applied NRC related to e.g. environmental chemistry, radiopharmaceutical chemistry and nuclear technologies is offered in addition to basic courses. In the Chalmers University of Technology the curriculum has mostly included general nuclear chemistry and nuclear technologies. However, new courses in radiopharmaceutical chemistry and radioecology have been added into the course supply starting from 2010. All courses are taught in English. Nuclear chemistry specialization in the University of Oslo has higher proportion for the diploma work (60 ECTS); the course portfolio has recently been updated as presented in Table 3.2.1.3.

In the University of Helsinki the radiochemistry specialization covers basic radiochemistry, radiation safety and measurement techniques as well as radioanalytical chemistry. In addition, a broad variety of applied radiochemistry such as environmental radioactivity, radiopharmaceutical

and radiation chemistry is taught; 3-4 of these elective courses should be included in the curriculum. Nuclear and radiochemistry education in the Norwegian University of Life Sciences is mainly focused on environmental radiochemistry, thus, the course supply for the radiochemistry specialization is similar to the curricula described later for Radioecology degree. Courses at UMB are taught in English.

Table 3.2.1.2: Selected curricula for general nuclear and radiochemistry at MSc level

Degree/specialization (University)	Courses and exams	Research training ¹	Diploma work ²	Total ECTS (degree total)
MSc in Nuclear Chemistry (University of Sofia)	30	15	15	60
MSc in Nuclear chemical engineering/ applied nuclear chemistry(CTU)	min 53	25	35	113/148 (120/180)
MSc in Nuclear engineering/ nuclear chemistry (TU Chalmers)	45	-	30	75 (120)
MSc in Chemistry/ nuclear chemistry (University of Oslo)	20-40	-	60	80-100 (120)
MSc in Chemistry/ radiochemistry (University of Helsinki)	40-41	3	40	83-84 (120)
MSc in Chemistry/ radiochemistry (UMB)	30	30	30	90 ³ (120)

¹Other than diploma work

²Literature survey plus experimental work

³Proportions given for the overall degree, specialization in NRC should include 90 ECTS

Table 3.2.1.3: NRC related courses under certain MSc degrees/specializations in general nuclear and radiochemistry

Degree	Course title	Credits	Type ¹
MSc in Nuclear Chemistry (University of Sofia)			
<i>obligatory</i>	Application of radionuclides in chemical investigations	5	L, P
	Chemistry of f- elements and transactinides	3	L, P
	Radioisotope methods in medicine	3	L, P
	Materials for the nuclear energetics	5	L, P
	Liability and resource in nuclear energetics	4	L, P
<i>elective</i>	Metrology of the ionizing radiation	3	L, P
	Programming in UNIX system	4	L, P
	Radiation biophysics	4	L, P
	Experimental physics and Moessbauer spectroscopy	4	L, P
	Fundamentals of the physics of nuclear reactors	3	L, P
MSc in Nuclear chemical engineering, specialization applied nuclear chemistry (CTU)			
<i>obligatory</i>	Basic nuclear chemistry II	5	L, E
	Detection and dosimetry of IR	4	L
	Basics of nuclear physics	6	L, E
	Separation methods in RC I	3	L
	Trace radiochemistry	3	L
	Radiation chemistry	3	L
	The Technology of the Fuel Cycles of NPP	2	L
	Environmental Chemistry and Radiation Hygiene	3	L
	Application of radionuclides I	2	L
	Radionuclide Production	2	L
	Practical exercises in RC I	5	P
	Practical exercises in RC II	6	P
Application of radionuclides II	2	L	

<i>elective</i>	Radioanalytical methods (RM)	3	L
	Separation methods in RC II	2	L
	The Chemistry of Operation of NPP	2	L
	Application of radiation methods	2	L
	Radiation methods in biology and medicine	2	L
	Chemistry of radioactive elements	2	L
	Quantum physics	3	L
	Technology of nuclear materials	2	L
	Labelled compounds (LC)	2	L
	Nuclear Power Plants Design and Operation	3	L, S
<hr/>			
MSc in Nuclear engineering, specialization nuclear chemistry (Chalmers University of Technology)			
	Nuclear Chemistry	7.5	L, P
	Applied Nuclear Chemistry	7.5	L, P
	Chemistry of Lanthanides, Actinides and Super-heavy Elements	7.5	L, P
	Solvent Extraction	7.5	L, P
<i>elective</i>	Radiopharmaceutical chemistry	7.5	L, P
	Radioecology and Radioanalytical Chemistry	7.5	L, P
<hr/>			
MSc in Chemistry, specialization nuclear chemistry (University of Oslo)			
<i>obligatory</i>	Radiochemical methods	10	L, E
	Laboratory exercises in radiochemistry	10	P
<i>elective</i>	Nuclear measurement techniques and instruments	10	L, P
	Radiopharmaceutical chemistry	10	L, E
<i>additional²</i>	Nuclear Technology	10	L, E
	Radiation and radiation measurement	10	L, E
	Nuclear Physics, structure and spectroscopy	10	L,ES
<hr/>			
MSc in Chemistry, specialization radiochemistry (University of Helsinki)			
<i>obligatory</i>	Basic Radiochemistry I	4	L
	Radiochemistry practicals	4	L, E, P
	Radiation safety	2	L, E, P
	Detection and measurement of radiations	5	L, E, P
	Analytical chemistry of radionuclides	5	L, P
<i>elective</i>	Environmental Radioactivity	3	L, S
	Chemistry of the nuclear fuel cycle	3	L
	Radiopharmaceutical chemistry	3	L, P
	Radiation chemistry	3	L, P
	Tracer techniques	3	L, P
	Atmospheric radioactivity	3	L
	Natural radioactive decay series and their use in environmental sciences	3	L, E
	Experimental course on radionuclide production	4	L, E, P
	Radionuclides diffusion in geomaterials; porosity and image analysis	4	L, E
<hr/>			
MSc in Chemistry, specialization radiochemistry (Norwegian University of Life Sciences)			
<i>obligatory</i>	Basic Radiochemistry	10	L, P
	Radioecology	10	L, P, E
<i>elective</i>	Risk assessment	5	L, E
	Ecotoxicology	15	L, S

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

3.2.2 Environmental radiochemistry and radioecology

In many European universities environmental radiochemistry is stated as the major or at least one the most important focuses in teaching nuclear and radiochemistry. Norwegian University of Life Sciences offers a full MSc degree in radioecology (120 ECTS) which is accredited with the European Master status and is taught completely in English. The program is open for students having an environmental related BSc degree, e.g. in chemistry, biology, environmental engineering, and average 10 national and international students are graduated with this degree per year. The Bulgarian Universities, University of Sofia and Plovdiv University have a program MSc in Radiochemistry and radioecology with 90 and 74 ECTS, respectively. In Sofia the curriculum is designed for students having a BSc degree in chemistry or chemistry-related fields; from 1 to 5 students are graduated annually from the program.

Specialization in environmental radiochemistry and/or radioecology is also possible under certain MSc programs in chemistry or environmental studies. In the Comenius University (Bratislava, Slovakia) chemistry students can specialize in nuclear chemistry and radioecology (100 ECTS). Average 5 students are graduated annually with this degree. In Poland, the University of Gdansk offers specialization in radiochemistry under the MSc degree in Environmental protection, with average 7 students graduating per year. There are also two engineering programs under which specialization in environmental radiochemistry is possible. In the Czech Technical University in Prague (CTU) MSc in Nuclear Chemical engineering includes specialization Chemistry of the environment; 7 students have graduated with this degree in the period of 2000-2009. In the University of Pannonia (Veszprem, Republic of Hungary) an MSc program in Environmental engineering with a specialization in radioecology started at 2009. Universities offering specialization in radiochemistry and/or radioecology at MSc level are listed in Table 3.2.2.1.

Table 3.2.2.1: Universities offering MSc degree or specialization in environmental radiochemistry and radioecology

University	Degree/specialization	Credit values
NORWEGIAN UNIVERSITY OF LIFE SCIENCES (UMB)	MSc in Radioecology	120 ECTS
SOFIA UNIVERSITY ST. KLIMENT OHRIDSKI	MSc in Radiochemistry and radioecology	90 ECTS
PLOVDIV UNIVERSITY	MSc in Radiochemistry and radioecology	74 ECTS
CZECH TECHNICAL UNIVERSITY IN PRAGUE (CTU)	MSc in Nuclear Chemical engineering * <i>chemistry of the environment</i>	180 ECTS 107
COMENIUS UNIVERSITY	MSc in Chemistry * <i>nuclear chemistry and radioecology</i>	120 ECTS 100
UNIVERSITY OF PANNONIA	MSc in Environmental engineering * <i>radioecology</i>	120 ECTS 47
UNIVERSITY OF GDANSK	MSc in Environmental protection * <i>radiochemistry</i>	120 ECTS 73

Curriculum of the selected programs is depicted in detail in Table. 3.2.2.2. Research training and/or diploma work (mostly consists of literature survey and experimental work) have typically high importance in specialization in the field of radioecology. On the other hand, requirements for specialized courses as well as course supply in NRC vary markedly. Contents of various curricula are compared in Tables 3.2.2.3. and 4.

Table 3.2.2.2. Contents of curriculum in certain MSc specializations in environmental

radiochemistry and radioecology

Degree	Courses and exams	Research training	Diploma work	Other, what	Total ECTS (degree total)
EurMSc in Radioecology (UMB)	30	30	60		120
MSc in Radiochemistry and radioecology (Sofia University)	50	16	20	4 project work	90
MSc in Nuclear chemical engineering: chemistry of the environment (CTU)	min 47	25	35		107 (120)
MSc in Chemistry: nuclear chemistry and radioecology (Comenius University)	42	14	29	15 seminars	100 (120)
MSc in Environmental engineering: radioecology (University of Pannonia)	17	-	30		47 (120)

Table 3.2.2.3. NRC related courses for certain MSc degrees/specializations in environmental radiochemistry and radioecology

Degree	Course title	Credits	Type ¹
EurMSc in radioecology (UMB)			
	Basic Radiochemistry	10	L, P
	Radioecology	10	L, P, E
	Risk assessment	5	L, E
<i>elective</i>	Ecotoxicology	15	L, S
MSc in radiochemistry and radioecology (Sofia University)			
	Radiochemistry	7	L, P
	Radiometry and dosimetry	6	L, P
	Fundamentals of radiobiology	3	L, P
	Radioecology	6	L, P
	Nuclear methods for analysis	6	L, P
<i>elective</i>	Radioactive wastes	4	L, P
	Application of radionuclides	5	L, P
	Chemistry of the f-elements	2	L, P
	Radioisotope dating	3	L, P

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

Table 3.2.2.4: NRC related courses for engineering programs with specialization in chemistry of the environment and radioecology

Degree	Course title	Credits	Type ¹
MSc in Nuclear chemical engineering, specialization chemistry of the environment (CTU)			
	Basic nuclear chemistry II	5	L, E
	Detection and dosimetry of IR	4	L
	Basics of nuclear physics	6	L, E
	Separation methods in RC I	3	L
	Trace radiochemistry	3	L
	Radiation chemistry	3	L
	The Technology of the Fuel Cycles of NPP	2	L
	Environmental Chemistry and Radiation Hygiene	3	L
	Practical exercises in RC I	5	P
	Practical exercises in RC II	6	P
	Radioanalytical methods (RM)	3	L
<i>elective</i>	Nuclear Power Plants Design and Operation	3	L, S
	The Chemistry of Operation of NPP	2	L
	Chemistry of radioactive elements	2	L
	Radiobiology	2	L
	Radiation protection	4	L

Determination of radionuclides in the environment	2	L
MSc in Environmental engineering, specialization radioecology (University of Pannonia)		
Decontamination in Nuclear Power Plant	2	L
Environmental radiations, radiation protection	2	L
Nuclear chemistry and application of radioisotopes	2	L
Radioactive waste disposal	2	L
Radioactive tracer methods	2	L
Radiation accident management	2	L
Radiation chemistry and technology	2	L
Radiation measurement	3	P

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

3.2.3 Miscellaneous specializations

One of the various fields of specialization in NRC is **radiopharmaceutical chemistry**. The Nuclear Chemical engineering program of the Czech Technical University in Prague (CTU) includes a specialization nuclear chemistry in biology and medicine. In collaboration with CTU, the Charles University in Prague offer nuclear chemistry specialization (under MSc in Chemistry) with the focus on radiopharmaceutical chemistry. At CTU average 3 three students are attending and 1 graduating with this specialization annually. There are also several other programs, mostly organized in collaboration with industry, under which related fields can be studied; some examples are included in Table 3.2.3.1. Moreover, numerous specializations/institutions may be missing as radiopharmaceutical chemistry is taught under various educational programs such pharmaceutical sciences or nuclear medicine degrees, all of which were not surveyed in this study.

Table 3.2.3.1: Examples of educational programs related to radiopharmaceutical chemistry

Degree/specialization	Educational institutions
MSc in Nuclear Chemical engineering/ nuclear chemistry in biology and medicine	Czech Technical University in Prague
MSc in Chemistry/ nuclear (radiopharm.) chemistry	Charles University
MSc in Radiopharmaceutics & PET Radiochemistry	King's College London (in collaboration with Cancer Research UK, GE Healthcare, Tyco, Siemens Medical, Imaging Equipment Ltd and the Engineering and Physical Sciences Research Council) http://www.kcl.ac.uk
MSc in Medical Nuclide Techniques: 2 nd year focus on radiochemistry	Uppsala University (in collaboration with Uppsala Imanet AB, GE Healthcare, AstraZeneca AB and Affibody AB) http://www.uu.se/en/node605?pKod=MMN2M&lasar=10%2F11
The Master's Degree Program in Biomedical Imaging	Jointly administrated by the Department of Biosciences at Åbo Akademi University and the Medical Faculty at the University of Turku https://www.abo.fi/student/en/biomedical_imaging
The postgraduate education for the title "Radiopharmaceutical Chemist/ Radiopharmacist" ¹	Joint program by the Institute of Pharmaceutical Sciences (ETH Zurich, Switzerland) in cooperation with the Faculty of Pharmacy (University of Ljubljana, Slovenia) and the Institute of Pharmacy (University of Leipzig, Germany) http://www.radiochem.pharma.ethz.ch/
European specialization certificate in radiopharmacy ²	European Association of Nuclear Medicine in collaboration with various institutions http://www.eanm.org/committees/radiopharmacy

^{1,2} *Post-graduate specialization certificate, modules can be included in PhD studies*

There are also various educational programs related to **nuclear energy and materials**; examples of French programs, which include mostly fuel cycle chemistry and nuclear waste management, are described in Table 3.2.2.2. Detailed information on these programs can be found in their web pages. Nuclear chemistry is also strongly involved in the engineering programs at KTH Royal Institute of Technology in Sweden and in Technical University of Delft (Netherlands). At KTH students with chemistry background can include courses in NRC (reactor chemistry, nuclear fuel cycle, photo-, radiation and radical chemistry, total 22.5 ECTS) and do a diploma work (30 ECTS) in NRC related fields under the degrees of MSc in Chemical engineering or MSc in Molecular Science and Engineering (120 ECTS). Average 30 students are graduated annually with this specialization. The chemical engineering program (105 ECTS) at TU Delft has a specialization in nuclear science and engineering (30-70 ECTS, courses on nuclear science, chemistry and radiological health physics); first students will be graduated from this program this year (2011).

In addition, XIOS Hogeschool Limburg (Belgium) has an academic nuclear engineering program (60 ECTS) with a specialization in nuclear technology. FH Aachen University of Applied Sciences (Germany) offers the degree EurMSc in Nuclear Applications. The program was started at 2003 and 52 students have graduated with this degree so far (annual average 10). In the University of Pannonia (Hungary) students can specialize in radiochemical technology (56 ECTS) under the degree MSc in Chemical engineering (120 ECTS). It is a relatively new program, started at 2009.

Table 3.2.3.2: Examples of French programs related to nuclear energy and materials

Degree/specialization	Educational institutions
MSc Nuclear Energy/ specialization nuclear fuel cycle	<u>Consortium I:</u> ParisTech (Ecole Polytechnique ParisTech – Mines ParisTech – Ecole des Ponts ParisTech – Arts et Métiers ParisTech – ENSTA ParisTech – Chimie ParisTech) Université Paris Sud (XI), Ecole Centrale Paris (ECP), Supelec, l'Institut National des Sciences et Techniques Nucléaires de Saclay (INSTN) http://www.master-nuclear-energy.fr/en/index.php
MSc Science of Materials/ specialization materials for energy (<i>Matériaux pour les structures et l'énergie</i>)	<u>Consortium II:</u> Université Paris Sud (XI), Université Paris XII, Chimie ParisTech, Mines ParisTech, Polytechnique ParisTech, ECP, INSTN http://www.enscp.fr/spip.php?rubrique148
MSc Sciences, Technology, Health – chemistry and applications/ specialization separation chemistry, materials, methods (<i>Chimie Séparative, Matériaux, Procédés</i>)	<u>Consortium III:</u> University Montpellier 2, l'Ecole Nationale Supérieure de Chimie de Montpellier (ENSCM), INSTN http://www.master-chimie.univ-montp2.fr/CSMP ;
MSc in Advanced Nuclear Waste Management	École des Mines of Nantes, Laboratory of Subatomic Physics and Associated Technologies (SUBATECH, in collaboration with University of Nantes and CNRS), Laboratory of radiochemistry http://www.mines-nantes.fr/fr/Formations/Masters-of-Science/SNEWM-ANWM

In addition to the above-mentioned specializations, some minor topics can be selected based on the contents of the curricula. For example, in Maria Curie Skłodowska University (Poland) specialization in radiochemistry is taught under the MSc degree in Analytical chemistry, and the curriculum covers mostly **analytical radiochemistry**.

3.3 The role of E-learning

The questionnaire contained also a question concerning the use of E-learning platform. Only 38% of the respondents confirmed that they are using some E-learning platform in course management. Typical programmes are Fronter, Blackboard or Moodle.

4 NUCLEAR AND RADIOCHEMISTRY EDUCATION AT PHD LEVEL

In most of the universities having education in nuclear and/or radiochemistry there is also possibility to do PhD-work in related fields, i.e. 93 % of the respondents described PhD-studies and altogether 247 projects were listed. Topics of the PhD-projects are categorized in Fig. 4.1. Average time allowed for a PhD-work in NRC is 3.9 years; 63% of the universities are using a monograph thesis and in 37% of the universities the thesis is comprised of scientific publications (from 2 to 5) and a summarizing report. Universities with largest group of PhD-students (currently over 10) and major topics of their work are listed in Table 4.1.

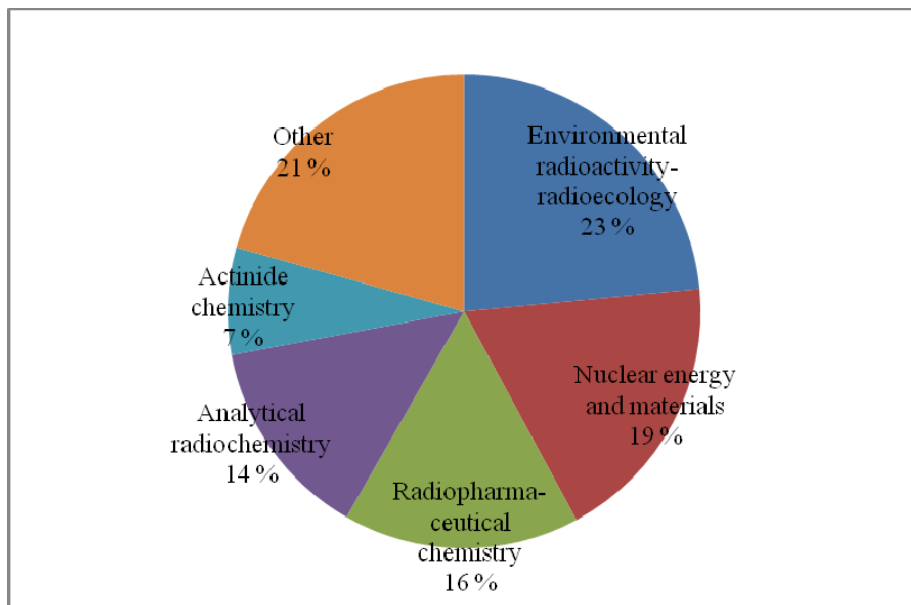


Figure 4.1: Topics of PhD-projects in nuclear and radiochemistry. The category Nuclear energy and materials include research projects related e.g. to fuel cycle chemistry and treatment of radioactive waste. Miscellaneous minor topics such as radionuclide production and radiation (materials) chemistry are included in the category Other.

Table 4.1: Universities with large group of PhD-students and major topics related to nuclear and radiochemistry

University	PhD topics
JOHANNES GUTENBERG UNIVERSITY, Germany	<ul style="list-style-type: none"> Development of radiopharmaceuticals for nuclear imaging (PET, SPECT) Development of targets for nuclear physics experiments Mass spectrometry of rare isotopes Laser spectroscopy of actinides and other radionuclides Sorption of actinides on mineral surfaces Chemistry of the heaviest elements Boron neutron capture therapy
UNIVERSITY OF BERN, Switzerland	<ul style="list-style-type: none"> Development of radionuclides for therapy Superheavy element chemistry Environmental radionuclides Atmospheric chemistry / Surface chemistry

	Analytical chemistry/ Paleo-climate research Rad-Waste Analytics
DRESDEN UNIVERSITY OF TECHNOLOGY, Germany	Complexation of actinides Sorption and migration studies of actinides and long-lived RN Interaction of actinides and long-lived RN with biological systems (microbes, plants, algae, bio-films)
CZECH TECHNICAL UNIVERSITY IN PRAGUE, Czech Republic	Radioactive Waste Treatment, Separations Repository sites and migration of contaminants Radioanalytical Methods Radiation Chemistry Radiopharmaceuticals and Labelled Compounds
UNIVERSITY OF HELSINKI, Finland	Development of radiopharmaceuticals for nuclear imaging (PET, SPECT) Radioecology Radiation/materials chemistry Long-term safety of final disposal of spent nuclear fuel (chemistry, migration and retention of radionuclides in the geosphere)
UNIVERSITY OF MANCHESTER, UK	Coordination chemistry of the radioactive elements Chemistry of radioactive wastes Environmental radiochemistry
<i>Nuclear First Training Centre</i>	Synthetic Radiochemistry of the actinides Chemical Modelling Geological disposal Fuel and reactor systems Environmental Radiochemistry

Universities having a PhD program in nuclear and/or radiochemistry are listed in Table 4.2. The extent of a PhD-degree is typically 60 ECTS plus a thesis work. Minority of the universities offer NRC related courses at PhD-level (see Table 4.3.), instead, courses are selected from various MSc course supply or from other programs at similar level.

Table 4.2: Universities having a PhD degree in nuclear and/or radiochemistry

University	PhD degree
University of Sofia	PhD in radiochemistry (180 ECTS, thesis included)
Czech Technical University in Prague	PhD in nuclear chemistry (no credit points used)
University of Helsinki	PhD in chemistry, specialization radiochemistry (60 ECTS)
University of Köln	PhD in chemistry, specialization NRC (no credit points used)
Norwegian University of Life Sciences	PhD in chemistry: specialization NRC
University of Oslo	PhD in chemistry, specialization nuclear chemistry (180 ECTS, thesis included)
University of Gdansk	PhD in chemistry, specialization NRC
University of Pannonia	PhD in chemistry, specialization radiochemistry
Comenius University	PhD in chemistry, specialization nuclear chemistry (240 ECTS, thesis included)
Chalmers University of Technology	PhD in chemistry, specialization nuclear chemistry (60 ECTS)

Table 4.3: Examples of NRC related courses at PhD level in various universities

University	Course title	Credits	Type ¹
Czech Technical University in Prague			
	Synthesis of LC	2	L
	Biosynthesis of LC	2	L
	Instr. RM for pollution monitoring of the environment	2	L
	Radionuclides in biological sciences	2	L
	Application of large ionizing radiation sources	2	L
	Application of radiation chemistry in chemical industry, agriculture and medicine	2	L
University of Helsinki			
	Radionuclides diffusion in geomaterials; porosity and image analysis	4	L, E
University of Oslo			
	Nuclear measurement techniques and instruments	10	L, P
	Radiopharmaceutical chemistry	10	L, E
University of Köln			
	Radiopharmaceutical Chemistry	1	L
	Labelling with radioisotopes	1	L
	Chemistry of Radioelements	1	L
	Radioanalytics in life sciences	1	L
	Radioanalytical aspects of research in nuclear data and nuclear energy research	2	L
	Radioanalytical inorganic chemistry	2	L

5 COUNTRY REPORTS

5.1 Austria

In Austria, nuclear and radiochemistry is taught in three universities: Vienna University of Technology, University of Vienna and University of Innsbruck. In the University of Innsbruck (Institute of Analytical Chemistry and Radiochemistry) course in basic radiochemistry/radioanalytics (2.5 ECTS) is offered for BSc students in Chemistry. The University of Vienna and Vienna University of Technology have a larger variety of NRC related courses. These courses are mainly studied under MSc in Physics or Chemistry. Neither of these universities has a complete (BSc, MSc) program in nuclear or radiochemistry, however, the Atomic Institute of the Austrian Universities (ATI) of TU Vienna offers various nuclear educational programs (also related to nuclear and radiochemistry) which both national and international students can join.

University of Vienna

Faculty of Chemistry, Institute of Inorganic Chemistry, Radiochemistry group

<http://anorg-chemie.univie.ac.at>

Tables 5.1.1. and 5.1.2. present topics of NRC related courses and current PhD-projects in the University of Vienna. Most of the courses are taught once/year and have 6-10 students attending. The group has 1 permanent staff member, 2 PhD students and 2 external lecturers participating in teaching. The education is focused on environmental radiochemistry.

Table 5.1.1: NRC related courses in the University of Vienna

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Radiochemistry I+II	2.5+1.5	German	L	MSc in Chemistry (E)
2	Radiochemistry Lab exercises	6	German	E	MSc in Chemistry (E)
3	Radiopharmaceutical chemistry	3	German	L	MSc in Chemistry (E)
4	Actinides chemistry	1	German	L	MSc in Chemistry (E)
5	Seminar	3	German	S	MSc in Chemistry (E)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

Table 5.1.2: Current PhD projects related to NRC in the University of Vienna

Research topic	Number of PhD-projects
U-236 in the environment	1
Sr-90 in soil and deer bones	1
I-129 in aerosol samples	1

Vienna University of Technology

Radiation Physics

<http://www.ati.ac.at/index.php?id=16&L=1>

The group has 5 persons (permanent staff) participating in teaching. No special focus is stated for the education; general radiochemistry courses (See Table 5.1.3.) are giving once/year and have average 5 students attending. Current PhD-projects are listed in Table 5.1.4.

Table 5.1.3: NRC related courses in the Vienna University of Technology

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Radiochemie 1	3	German	L	MSc in Physics
2	Radiochemisches Praktikum	5	German	P	or Chemistry (E)
3	Projektarbeit aus Radiochemie	10	German	P	
4	Environmental INAA	3	English	L	

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

Table 5.1.4: Current PhD projects related to NRC in the Vienna University of Technology

Research topic	Number of PhD-projects
Migration studies on natural radionuclides	1
Provenancing objects of cultural heritage by NAA	1
Preparation of a silicate in house reference material	1

5.2 Belgium

NRC related education in Belgium is mostly focused on nuclear energy and materials, for a degree MSc in Nuclear Engineering. Six Belgian universities (Université de Liège, Université Catholique de Louvain, Universiteit Gent, Katholieke Universiteit Leuven, Université Libre de Bruxelles and Vrije Universiteit Brussel) in association with the Belgian nuclear research centre (SCK•CEN) forms a Belgian Nuclear Higher Education Network responsible for this education. Ghent University offers also some courses of Radiochemistry for BSc students of chemistry or other educational programs. In addition, the XIOS Hogeschool Limburg (<http://www.xios.be/>) has an industrial nuclear engineer program (60 ECTS) with specialization in environmental technology–radiochemistry or nuclear technology–medical nuclear technology.

Ghent University

Faculty of Sciences, Department of Analytical Chemistry

www.analchem.ugent.be

NRC related courses at Ghent University are listed in Table 5.2.1. From 35 to 69 BSc students are attending these courses every year. Furthermore, currently the group has one PhD-project related to Neutron activation analysis (NAA). One permanent staff member and 3 PhD students are participating in teaching radiochemistry in the department.

Table 5.2.1: NRC related courses in Ghent University

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Radiochemistry	3	Dutch	L, E, P	BSc in Chemistry (O)
2	Analytical Biochemistry, partim Radiochemistry	5/3	Dutch	L, P	BSc in Biochemistry and Biotechnology (O)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

5.3 Bulgaria

There are two universities in Bulgaria which both offer specialized education in nuclear and radiochemistry: Sofia University (St. Kliment Ohridski) and Plovdiv University (Paisii Hilendarski).

Sofia University St. Kliment Ohridski

Faculty of Chemistry, Department of Analytical Chemistry

<http://www.chem.uni-sofia.bg/depart/achem/default.htm>

NRC education in the University of Sofia is highly versatile, although following focuses on the education are stated:

- Radioecology and radioanalytical chemistry
- Radioactive waste: studies on the influence of different cement additives on the leaching of radionuclides, incorporated in cement matrix.
- Mechanochemistry of 5f-elements
- Application of radionuclides: studies on the influence of radioactive additives on the photocatalytic behaviour of TiO₂.

The complete programs in NRC are described in Table 5.3.1. First students in BSc in Nuclear Chemistry were graduated in 2010; MSc in Nuclear Chemistry is also a new program starting from autumn 2010. Average number of students attending in these programs is estimated as 5-12 at BSc level and 1-5 at MSc level. In addition, some courses on NRC are giving to BSc students in chemistry or chemistry-related programs, see Table 5.3.2. Currently there are two PhD-projects under the research field Determination and evaluation of the distribution of selected radionuclides in the environment. The department has total 15 persons participating in teaching, 10 permanent staff members, 3 external lecturers and 2 PhD students.

Table 5.3.1: NRC related educational programs in the University of Sofia

Degree	Courses	Final exam(s)	Research training	Diploma work	Other, what?	Total
BSc in Nuclear Chemistry	226	40	4	10		240
(I) MSc in Nuclear Chemistry	30	8	15	15		60
(II) MSc in Radiochemistry and radioecology	50	10	16	20	Course project (4)	90
PhD in Radiochemistry	35	4	130		Research seminars (15)	180

Table 5.3.2: NRC related courses in the University of Sofia

Title	Credits	Language	Type ¹	Target group ² (O/E ³)
Atomic and nuclear physics	9	Bulgarian	L, E	BSc (O)
Nuclear chemistry and radiochemistry - I	7	Bulgarian	L, P	BSc (O)
Measurement of the ionization radiation	6	Bulgarian	L, P	BSc (O)
Radiation protection	4	Bulgarian	L, S	BSc (O)
Nuclear chemistry and radiochemistry - II	6	Bulgarian	L, P	BSc (O)
Operation and decommissioning of nuclear power plants	6	Bulgarian	L, P	BSc (O)
Radioanalytical chemistry	6	Bulgarian	L, P	BSc (O)
Radioanalytical chemistry	3	Bulgarian	L, P	BSc (E) for students in "Chemistry" or chemistry-related program
Chemistry of the nuclear fuel cycle and of nuclear reactors	8	Bulgarian	L, P	BSc (O)
Water treatment and water purification in the nuclear energetic	4	Bulgarian	L, P	BSc (O)

Radioecology	4	Bulgarian	L, P	BSc (O)
		Bulgarian	L, P	<i>BSc (E) for students in "Chemistry" or chemistry-related program</i>
Radioecology	3			
Production of radioactive isotopes and labeled compounds	5	Bulgarian	L, P	BSc (O)
Radioactive wastes	5	Bulgarian	L, E	BSc (O)
Nuclear safety. Risk analysis and risk informed decision making	3	Bulgarian	L, S	BSc (O)
Fundamentals of radiobiology	4	Bulgarian	L, P	BSc (O)
Hot atom chemistry	4	Bulgarian	L, P	BSc (E)
Radioisotope dating	4	Bulgarian	L, P	BSc (E)
Radionuclide methods in medicine	4	Bulgarian	L, P	BSc (E)
Materials for the nuclear energetics	4	Bulgarian	L, E	BSc (E)
Application of radionuclides	4	Bulgarian	L, P	BSc (E)
Application of radionuclides in chemical investigations	5	Bulgarian	L, P	MSc1 (O)
Chemistry of f- elements and transactinides	3	Bulgarian	L, P	MSc1 (O)
Radioisotope methods in medicine	3	Bulgarian	L, P	MSc1 (O)
Materials for the nuclear energetics	5	Bulgarian	L, P	MSc1 (O)
Liability and resource in nuclear energetics	4	Bulgarian	L, P	MSc1 (O)
Metrology of the ionizing radiation	3	Bulgarian	L, P	MSc1 (E)
Programming in UNIX system	4	Bulgarian	L, P	MSc1 (E)
Radiation biophysics	4	Bulgarian	L, P	MSc1 (E)
Experimental physics and Moessbauer spectroscopy	4	Bulgarian	L, P	MSc1 (E)
Fundamentals of the physics of nuclear reactors	3	Bulgarian	L, P	MSc1 (E)
Radiochemistry	7	Bulgarian	L, P	MSc2 (O)
Radiometry and dosimetry	6	Bulgarian	L, P	MSc2 (O)
Fundamentals of radiobiology	3	Bulgarian	L, P	MSc2(O)
Radioecology	6	Bulgarian	L, P	MSc2 (O)
Nuclear methods for analysis	6	Bulgarian	L, P	MSc2(O)
Radioactive wastes	4	Bulgarian	L, P	MSc2(E)
Application of radionuclides	5	Bulgarian	L, P	MSc2(E)
Chemistry of the f-elements	2	Bulgarian	L, P	MSc2(E)
Radioisotope dating	3	Bulgarian	L, P	MSc2(E)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² As in Table 5.3.1.

³ Obligatory = O, Elective = E

Plovdiv University

Faculty of Chemistry

<http://en.argon.uni-plovdiv.bg/>

Plovdiv University has an MSc program in Radiochemistry and radioecology (74 ECTS). The curriculum consists of 59 ECTS of courses and exams and 15 ECTS for the diploma work; current course offer (data from the university web pages) is listed in Table 5.3.2. Apparently the degree is aimed at students with certain background education (BSc in Chemistry or Physics) in the Plovdiv University, no detailed information was provided.

Table 5.3.2: NRC related courses in the University of Plovdiv

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Fundamentals of nuclear physics	7	Bulgarian	L, E	MSc I (O)
2	Fundamentals of radiochemistry	4	Bulgarian	L, E	MSc I (O)
3	Radiobiology and dosimetry	4	Bulgarian	L, E	MSc I (O)
4	Radioecology	5	Bulgarian	L, E	MSc I (O)
5	Scientific research practice	4	Bulgarian	E	MSc I (O)
6	Chemistry of the f-elements	4	Bulgarian	E	MSc I (E)
7	Nuclear chemistry	4	Bulgarian	E	MSc I (E)
8	Coordination chemistry	4	Bulgarian	E	MSc I (E)
9	Geochemistry	4	Bulgarian	E	MSc I (E)
10	Nuclear waste and decommissioning of nuclear facility	4	Bulgarian	E	MSc I (E)
11	Nuclear methods for analysis	4	Bulgarian	E	MSc I (O)
12	Application of radionuclides	4	Bulgarian	E	MSc I (O)
13	Technology for fluid purification	4	Bulgarian	E	MSc I (O)
14	Scientific research practice	7	Bulgarian	E	MSc I (O)
15	Nuclear medicine	4	Bulgarian	E	MSc I (E)
16	Biomonitoring and bioindication in radioactive environment	4	Bulgarian	E	MSc I (E)
17	Ecology of plants and animals in radioactive environment	4	Bulgarian	E	MSc I (E)
18	X-ray structure analysis	4	Bulgarian	E	MSc I (E)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

5.4 CROATIA

University of Zagreb (in collaboration with Rudjer Boskovic Institute)

Faculty of Science and Mathematics, Section Chemistry

www.pmf.hr

The Section of Chemistry offers basic radiochemistry course for BSc students in chemistry and radiation chemistry course for MSc students in Physical Chemistry. Both courses include lectures and seminars and have 5-10 students attending annually. The research fields are Physico-chemical Effects of Ionizing Radiations in Materials and Modification of Polymers, both of which has currently two PhD-projects running. Four permanent staff members and 2 PhD students are participating in teaching NRC in the section.

5.5 CYPRUS

University of Cyprus

Department of Chemistry

<http://www.ucy.ac.cy/goto/chemistry/en-US/HOME.aspx>

Nuclear and radiochemistry is taught under studies for environmental chemistry. Students both at BSc and MSc level can choose courses in basic radiochemistry (4 ECTS) and environmental radioactivity (3 ECTS), including lectures and seminars. Average number of students attending these courses annually is 15-20 and 5-10, respectively. In addition, PhD work can be carried out in the field of environmental radioactivity; current topics are Aquatic chemistry of uranium and Environmental radiometry. The department has 5 permanent staff members and 2 PhD students participating in teaching NRC.

5.6 CZECH REPUBLIC

In Czech Republic there are several universities/institutions giving education in nuclear and radiochemistry. The Czech Technical University in Prague (CTU) and the Charles University offer educational programs in NRC at various levels. In addition, separate courses related to NRC are given at the Masaryk University, University of Defence in Brno and the Chemical Institute of Technology Prague.

Czech Technical University in Prague, CTU

Faculty of Nuclear Sciences and Physical Engineering, Department of Nuclear Chemistry

www.cvut.cz; www.fffi.cvut.cz/kjch

CTU offers NRC related education from BSc to PhD level. No specific areas of education are stated, instead, the curricula cover all fields of NRC. Complete programs in NRC are described in Table 5.6.1. and detailed information on the course offer is listed in Table 5.6.2. At MSc level the degree MSc in Nuclear chemical engineering can be taken either as a 2 year (120 ECTS) or a 3 year (180 ECTS) program. Average 3 students are graduating with the BSc degree and 2 students from each MSc program annually. Furthermore, there are 26 PhD projects running in the department (13 external students), the research topics are listed in Table 5.6.3. The key staff in teaching at CTU consists of 13 permanent members. Furthermore, 12 external lecturers and 1-2 PhD students are participating in teaching.

Table 5.6.1: NRC related educational programs at CTU

Degree / Specialization	Courses	Research training (other than diploma work)	Diploma work	ECTS Total (degree total)
BSc in Nuclear chemical engineering (NRE)	19-22	1	15	35-38 (180)
(I) MSc in NRE / Applied Nuclear Chemistry	min 53	25 (+16 in the 1 st year)	35	min 113 (120/180)
(II) MSc in NRE / Chemistry of the environment	min 47	25 (+16 in the 1 st year)	35	min 107 (120/180)
(III) MSc in NRE / NC in biology and medicine	min 49	25 (+16 in the 1 st year)	35	min 109 (120/180)
PhD in Nuclear chemistry		no credit points used*		

* 4-6 obligatory specialized lectures (+1-2 languages) finalized with exams

Table 5.6.2: NRC related courses at CTU

Title	Credits	Language	Type ¹	Target group ² (O/E ³)
Basic nuclear chemistry I	4	Czech	L, E	BSc (O)
Basic nuclear chemistry II	5	Czech, English	L, E	BSc, MSc I-III (O)
Detection and dosimetry of IR	4	Czech, English	L	BSc, MSc I-III (O)
Nuclear Power Plants Design and Operation	3	Czech	L, S	BSc, MSc I-III (E)

Basics of nuclear physics	6	Czech	L, E	BSc, MSc I-III (O)		
				MScI	MScII	MScIII
Separation methods in RC I	3	Czech	L	O	O	O
Trace radiochemistry	3	Czech	L	O	O	O
Radiation chemistry	3	Czech, English	L	O	O	O
The Technology of the Fuel Cycles of NPP	2	Czech	L	O	O	-
Environmental Chemistry and Radiation Hygiene	3	Czech	L	O	O	O
Application of radionuclides I	2	Czech	L	O	-	-
Radionuclide Production	2	Czech	L	O	-	O
Practical exercises in RC I	5	Czech, English	P	O	O	O
Practical exercises in RC II	6	Czech, English	P	O	O	O
Radioanalytical methods (RM)	3	Czech, English	L	O	O	E
Separation methods in RC II	2	Czech	L	E	-	E
The Chemistry of Operation of NPP	2	Czech	L	E	E	-
Application of radiation methods	2	Czech	L	E	-	O
Radiation methods in biology and medicine	2	Czech	L	E	-	O
Chemistry of radioactive elements	2	Czech, English	L	E	E	E
Quantum physics	3	Czech	L	E	-	-
Technology of nuclear materials	2	Czech	L	E	-	-
Labelled compounds (LC)	2	Czech	L	E	-	E
Radiobiology	2	Czech	L	-	E	E
Radiation protection	4	Czech	L	-	E	E
Determination of radionuclides in the environment	2	Czech	L	-	E	-
Radiopharmaceuticals	2	Czech	L	-	-	O
Application of radionuclides II	2	Czech	L	O	-	-
Synthesis of LC	2	Czech	L	PhD		
Biosynthesis of LC	2	Czech	L	PhD		
Instr. RM for pollution monitoring of the environment	2	Czech	L	PhD		
Radionuclides in biological sciences	2	Czech	L	PhD		
Application of large ionizing radiation sources	2	Czech	L	PhD		
Application of radiation chemistry in chemical industry, agriculture and medicine	2	Czech	L	PhD		

Table 5.6.3: Current PhD projects related to NRC at CTU

Research topic	PhD projects
Radioactive Waste Treatment, Separations	6
Repository sites and migration of contaminants	5
Radioanalytical Methods	6
Radiation Chemistry	6
Radiopharmaceuticals and Labelled Compounds	4

Charles University

Faculty of Science, Department of Organic and Nuclear Chemistry

<http://web.natur.cuni.cz/www/en/index.php>

At the Charles University basic radiochemistry can be studied e.g. under BSc studies for chemistry or environmental chemistry. At MSc level it is possible to specialize in nuclear chemistry; 2-4 students take this specialization annually. The general curriculum is carried out together with CTU, education at the Charles University if focused on radiopharmaceutical chemistry. The current two PhD projects are also focused on Development and analysis of radiopharmaceuticals for positron and single photon emission tomography (PET, SPECT). The department has 3 permanent staff members, 3 PhD students and 5 external lecturers participating in teaching.

Table 5.6.4: NRC related courses at the Charles University

	Title	Credits	Language	Type ¹	Target group ² (O/E ³)
1	Basic RadiochemistryA	4	Czech	L,S	BSc (O)
	Basic RadiochemistryA	3	Czech	P	BSc
2	Basic Radiochemistry B	3	Czech	L, P(O)	BSc (O)
	Basic Radiochemistry B	3	Czech	P	BSc
3	Separation methods*	5	Czech	L,	MSc1 NRC(O)
4	Radiation hygiene*	2	Czech	L	MSc1 NRC (O)
5	Chemistry of rad. elements*	4	Czech	L	MSc1 NRC (O)
6	Diploma work	7	Czech	P	MSc1 NRC (O)
7	Labelled compounds	3	Czech	L	MSc1 NRC (O)
8	Nuclear chemistry II*	4	Czech	L,S	MSc1 NRC (O)
9	Nuclear chemistry II*	4	Czech	P	MSc1 NRC (O)
10	Diploma work	10	Czech	P	MSc1 NRC (O)
11	Radiopharmaceuticals	3	Czech	L	MSc2 NRC (O)
12	Radiation chemistry*	5	Czech	L	MSc2 NRC (O)
13	Diploma work	22+25	Czech	P	MSc2 NRC (O)

* taught at CTU

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² MSc1 apparently cobined form of study, MSc2 specialization at the Charles University

³ Obligatory = O, Elective = E

Masaryk University

Faculty of Science, Department of Chemistry

www.sci.muni.cz

At the Masaryk University e.g. chemistry and biophysics students at all levels (BSc-PhD) can include in their studies courses on general radiochemistry (lectures+practicals 4+4 ECTS) and environmental radioactivity (3 ECTS). The department has 3 permanent staff members in teaching, however, no PhD projects in the field of NRC.

The Chemical Institute of Technology Prague, ICTP

Faculty of Chemical Engineering, Department of Analytical Chemistry

<http://www.vscht.cz/anl/>

The Institute has a research group on radioanalytical and separation methods. Currently there are 2 PhD projects under the topic Migration of radionuclides and bio-toxic components in the environment.

Furthermore, courses on radioanalytical methods (4 ECTS) are given to MSc students in analytical chemistry. The number of permanent staff members participating in teaching is 7.

University of Defence

<http://www.vojenskaskola.cz/school/ud/nbcdi/Pages/default.aspx>

In the University of Defence course on nuclear chemistry (4 ECTS) is taught, together with e.g. radiation protection and dosimetry, at BSc level for students in Military chemistry and Economics and management. Furthermore, there is a PhD project under the topic Determination of military significant alpha and beta radionuclides by means of solid state and liquid scintillation spectrometry. The key staff in teaching consists of 3 permanent staff members, 3 PhD students as well 1 external lecturer.

5.7 FINLAND

In Finland, the Laboratory of Radiochemistry in the University of Helsinki is the only academic institute giving a full-scale education in radiochemistry. General radiochemistry and specialized courses on radiopharmaceutical chemistry can also be studied in the University of Turku, and as individual courses (BSc studies in biosciences) in some other universities such as University of Oulu and University of Eastern Finland.

University of Helsinki

Department of Chemistry, Laboratory of Radiochemistry

<http://www.helsinki.fi/kemia/radiokemia/english>

In the Laboratory of Radiochemistry NRC related education is offered from BSc to PhD level. Detailed information on the course offer is described in Table 5.7.1. Basic radiochemistry course (4 ECTS) is offered for students in chemistry already at BSc level. Specialization in radiochemistry (83-84 ECTS) can be taken under the degree MSc in Chemistry (120 ECTS). Average 8 students are attending and 4 graduating from this program every year. The curriculum consists of 40-41 ECTS of courses and exams, 3 ECTS of research training (other than diploma work) and 40 ECTS of diploma work. Furthermore, there are 13 PhD projects running in the laboratory; the research topics are listed in Table 5.7.2. Ten permanent staff members, 5-8 external lecturers as well as all PhD students are participating in teaching NRC.

Table 5.7.1: NRC related courses in the University of Helsinki

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Basic Radiochemistry I	4	Finnish	L	BSc (E), MSc I (O)
2	Radiochemistry practicals	4	Finnish	L, E, P	MSc I (O)
3	Radiation safety	2	Finnish	L, E, P	MSc I (O)
4	Detection and measurement of radiations	7	Finnish	L, E, P	MSc I (O)
5	Analytical chemistry of radionuclides	7	Finnish	L, P	MSc I (O)
6	Advanced laboratory work in RC	3	Finnish	P	MSc I (O)
7	Environmental Radioactivity	3	Finnish	L, S	MSc I (E)
8	Chemistry of the nuclear fuel cycle	3	Finnish	L	MSc I (E)
9	Radiopharmaceutical chemistry	3	Finnish	L, P	MSc I (E)
10	Radiation chemistry	3	Finnish	L, P	MSc I (E)
11	Tracer techniques	3	Finnish	L, P	MSc I (E)
12	Atmospheric radioactivity	3	Finnish	L	MSc I (E)
13	Natural radioactive decay series and their use in environmental sciences	3	Finnish	L, E	MSc I (E)
14	Experimental course on radionuclide production	3	English	L, E, P	MSc I (E)

15	Radionuclides diffusion in geomaterials; porosity and image analysis	4	English	L, E	PhD
	Qualification of a radiation safety officer	1	Finnish/ English	exam	MSc I, PhD

If course 1 is included in BSc degree, 4 elective courses are required for MSc degree.

Courses 1-3, 7, 9, 11, 13 often also for students in other educational programs.

Courses 7-13 for PhDs if not included in MSc degree.

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

Table 5.7.2: Current PhD projects related to NRC in the University of Helsinki

Research topic	PhD-projects
Development of radiopharmaceuticals for nuclear imaging (PET, SPECT)	3
Radioecology	3
Long-term safety of final disposal of spent nuclear fuel (chemistry, migration and retention of radionuclides in the geosphere)	5
Radiation/materials chemistry	2

University of Turku

Faculty of Mathematics and Natural Sciences, Department of Chemistry

<http://www.sci.utu.fi/kemia/en/>

In the University of Turku courses on Basic radiochemistry, Chemistry of PET-radiopharmaceuticals and Radiochemical measuring techniques (total 16 ECTS) are offered for MSc students in chemistry, specialization organic and biological chemistry. In addition, there are several PhD projects related to radiopharmaceutical chemistry under various education programs in collaboration with Turku PET Centre and Åbo Akademi.

5.8 FRANCE

NRC education in France is currently under a substantial change. Majority of the NRC related education is given under joint educational programs which are described in Table 5.8.1. Furthermore, collaboration with research institutes, especially with l'Institut National des Sciences et Techniques Nucléaires (INSTN), has a strong role in education.

Table 5.8.1: Three major educational programs related to NRC in France

Consortium of Universities	Program
<u>Consortium I:</u> ParisTech (Ecole Polytechnique ParisTech – Mines ParisTech – Ecole des Ponts ParisTech – Arts et Métiers ParisTech – ENSTA ParisTech – Chimie ParisTech) Université Paris Sud (XI), Ecole Centrale Paris (ECP), Supelec, l'Institut National des Sciences et Techniques Nucléaires de Saclay (INSTN) http://www.master-nuclear-energy.fr/en/index.php	1) MSc Nuclear Energy; specialization nuclear fuel cycle
<u>Consortium II:</u> Université Paris Sud (XI), Université Paris XII, Chimie ParisTech, Mines ParisTech, Polytechnique ParisTech, ECP, INSTN http://www.enscp.fr/spip.php?rubrique148	2) MSc Science of Materials; specialization materials for energy (<i>Matériaux pour les structures et l'énergie</i>)

Consortium III: University Montpellier 2, l'Ecole Nationale Supérieure de Chimie de Montpellier (ENSCM), INSTN
<http://www.master-chimie.univ-montp2.fr/CSMP> ;
<http://www-instn.cea.fr/-Chimie-separative-materiaux-et-.html?lang=fr>

3) MSc Sciences, Technology, Health – chemistry and applications; specialization separation chemistry, materials, methods (*Chimie Séparative, Matériaux, Procédés*)

Paris Sud University XI

Radiochemistry Group

http://www.dep-chimie.u-psud.fr/index.php?option=com_wrapper&view=wrapper&Itemid=169

NRC related education at the Paris Sud University XI is focused on actinides radiochemistry. In the program MSc Nuclear Energy, the contribution is in general radiochemistry. Furthermore, there are 6 PhD projects under the field Radiochemistry. The department has 14 permanent staff members participating in teaching.

École nationale supérieure de chimie de Paris (Chimie Paris Tech)

Nuclear Science Division

<http://www.chimie-paristech.fr/spip.php?page=english>

NRC related courses at the Chimie Paris Tech are listed in Table 5.8.2. In the program MSc Nuclear Energy education at the Chimie Paris is profiled on Fuel cycle engineering. The program started at 2009, estimated number of students graduating annually is 20. Furthermore, there are several PhD projects in NRC related fields, such as solvent extraction and materials chemistry. Ten permanent staff members and 40 external lecturers are participating in teaching NRC in the department.

Table 5.8.2: NRC related courses at Chimie Paris Tech

	Title	Credits	Language	Type ¹	Level
1	Radioactivity	1	French	L, E	BSc
2	The nuclear fuel and the front-end of the nuclear fuel	5	English	L, E	MSc
3	Nuclear spent fuel recycling	5	English	L, E	MSc
4	Waste conditioning	4	English	L, E	MSc
5	Radioactive waste management and repository design	4	English	L, E	MSc
6	Process simulation and process control	4	English	L, P	MSc

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

In addition to the universities participating in the above mentioned programs, three other universities/institutes are giving education in NRC to various extents. **École des Mines of Nantes** has a MSc program in Advanced Nuclear Waste Management containing a minor part of NRC. At **GRENOBLE INP Phelma** (in collaboration with EDF and CEA – INSTN) offers Materials for nuclear energy qualification (MaNuEn) and also some courses for PhD studies. At the **Université de Nice-Sophia** courses on environmental radioactivity are given both at BSc and MSc level (less than 0.5 credits) and radioanalytical chemistry course at MSc level (1 credit). Furthermore, there are 2 PhD students in the field of radiochemistry at the department of radioecology.

5.9 GERMANY

Collaboration between universities and research institutes has a strong role in NRC education in Germany. A large part of the university education is still given at certificate or diploma level. At higher, BSc or MSc level, nuclear and radiochemistry is typically taught as course modules and a

diploma work can be done in related fields.

Ruprecht-Karl University of Heidelberg (collaboration with Karlsruhe Institute of Technology)

Faculty of Chemistry and Geoscience, Department of Physical Chemistry

<http://www.uni-heidelberg.de/fakultaeten/chemgeo/pci/>

In the University of Heidelberg chemistry students both at BSc and MSc level can take courses on radiochemistry and do a diploma work in NRC related fields; contents of the curricula and course supply are described in Tables 5.9.1. and 2. Average 25 and 10 students attend these programs annually. Topics of the current PhD projects are listed in Table 5.9.3. The department has 5 permanent staff members and 6 PhD students participating in teaching NRC.

Table 5.9.1: NRC related educational programs in the University of Heidelberg

Degree/module	Courses	Final exam(s)	Research training (other than diploma work)	Diploma work	Total
BSc in Chemistry/RC	12	-	3	12	27
MSc in Chemistry/RC	6	-	4	30	40

Table 5.9.2: NRC related courses in the University of Heidelberg

	Title	Credits	Language	Type ¹	Target group ² (O/E ³)
1	Basic Radiochemistry I	6	German	L, E	BSc (E)
2	Basic Radiochemistry II	9	German	L, E, P	BSc (E)
3	Radiopharmaceutical chemistry	5	German	L, P	MSc (E)
4	Chemistry of f-elements	5	German	L, P	MSc (E)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² As in Table 5.9.1.

³ Obligatory = O, Elective = E

Table 5.9.3. Current PhD projects related to NRC in the University of Heidelberg

Research topic	PhD-projects
Partitioning and Transmutation	2
High temperature fluorescence spectroscopy	1
Coordination chemistry of actinides	1

Dresden University of Technology (collaboration with Forschungszentrum Dresden-Rossendorf)

Faculty of Science, Dept. Chemistry/Food Chemistry, Professorship Radiochemistry

<http://www.chm.tu-dresden.de/anc2/>

NRC related education at TU Dresden is focused on following topics:

- Fundamentals in Nuclear and Radiochemistry
- Nuclear fuel cycle
- Production and application of radioisotopes in nuclear medicine
- Synthesis of radioactive labelled compounds
- Measurement of radioactivity
- Interaction of radiation with materials
- Actinide chemistry

MSc students in Chemistry can include their studies a course module in Radiochemistry; average number of students attending the program annually is 30 (6 graduates). Additional course entitled as Environmental Chemistry and Radiochemistry is offered for students under various educational programs. The department has only 2 permanent staff members participating in teaching NRC, however, the number PhD students is as high as 15. Topics of the current research projects are listed

in Table 5.9.4.

Table 5.9.4: Current PhD projects related to NRC at the TU Dresden

Research topic	PhD-projects
Complexation of actinides	7
Sorption and migration studies of actinides and long-lived RN	3
Interaction of actinides and long-lived RN with biological systems (microbes, plants, algae, bio-films)	5

University of Köln (collaboration with Forschungszentrum Jülich, Max Planck Institute)
Faculty of Science, Department of Chemistry, Division of Nuclear Chemistry at the Institute of Biochemistry

http://www.uni-koeln.de/math-nat-fak/nukchem/index_e.htm

NRC related education at the University of Köln is focused on following topics:

- Radiopharmacy
- Nuclear data measurement
- Fundamental radiochemistry
- Environmental radiochemistry

NRC related curricula and the overall course supply are listed in Table 5.9.5. and 6. Chemistry students both at BSc and MSc level can include their studies a module in Radiochemistry and do a diploma work in related fields. Average number of students graduating with the BSc degree is 9, first complete MSc program started in 2010. In addition, MSc and PhD students in geology and physics attend the courses regularly. Furthermore, there is possibility to do PhD work in applied NRC; topics of the current research projects are listed in Table 5.9.7. Six permanent staff members (2 employed by the Research Centre Jülich and Max Planck Institute) and 5 PhD students are participating in teaching NRC.

Table 5.9.5: NRC related educational programs in the University of Köln

Degree/module	Courses	Final exam(s)	Research training (other than diploma work)	Diploma work	Total*
BSc in Chemistry/RC	7		4	14	11/25
MSc in Chemistry/RC	6		7	30	13/43

* in both cases (BSc/MSc) the student can choose only the module or both module and diploma work

Table 5.9.6: NRC related courses in the University of Köln

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Basic Nuclear chemistry	2	German	L	BSc (O)
2	Exercises in Basic Nuclear chemistry	2	German	E	BSc (O)
3	Lab Course in Nuclear chemistry	5	German, English possible	P	BSc (O)
4	Seminar in Nuclear chemistry	2	German	S	BSc (O)
5	Lab Course in Nuclear chemistry II	5	German, English possible	P	MSc(O)
6	Radiopharmaceutical Chemistry	1	German	L	MSc(E), PhD (E)
7	Labelling with radioisotopes	1	German	L	MSc(E) , PhD (E)
8	Chemistry of Radioelements	1	German	L	MSc(E) , PhD (E)
9	Radioanalytics in life sciences	1	German	L	MSc(E) , PhD (E)

10	Radioanalytical aspects of research in nuclear data and nuclear energy research	2	German	L	MSc(E) , PhD (E)
11	Radioanalytical inorganic chemistry	2	German	L	MSc(E) , PhD (E)
12	Seminar Nuclear Chemistry	1	English,	S	All (E)
2	Nuklearchemisches Seminar		German		

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

²Obligatory = O, Elective = E

Table 5.9.7: Current PhD projects related to NRC in the University of Köln

Research topic	PhD-projects
Development of radiopharmaceuticals for nuclear imaging	5
AMS measurements (exposure dating, nuclear forensics of Pu)	-
Radiochemical separation procedures and nuclear data measurements	2
Environmental behaviour of nuclear waste	1

FH Aachen-University of Applied Sciences

Speciality Chemistry and Biotechnology, Nuclear Chemistry

http://www.fh-aachen.de/nuclear_applications.html

The University of Applied Sciences has two educational programs which include nuclear and radiochemistry: BSc in Applied Chemistry (180 ECTS) and MSc in Nuclear Applications (120 ECTS). Proportion of NRC in these programs varies from 10-40 ECTS at BSc level and 30-90 at MSc level, respectively. The overall course offer is listed in Table 5.9.7. Average 5 students are graduating with the BSc degree and average 10 with the MSc degree annually. The department has 1 permanent staff member and 2 external lecturers in teaching NRC.

Table 5.9.8: NRC related courses at the University of Applied Sciences

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Nuclear Chemistry	7	German	L, E, P	BSc (O)
2	Radioanalytical Methods	3	German	L, E, P	BSC (E)
3	Nuclear Chemistry	10	English	L, E, P	MSc (O)
4	Nuclear Physics and Rad. Detection	10	English	L, E, P	MSc (O)
5	Nuclear Applications	10	English	L	MSc (O)
6	Advanced Radiochem. Methods	10	English	L, E, P	MSc (E)
7	Radioecology	10	English	L, E, P	MSc (E)
8	Biomedical Applications	10	English	L, E, P	MSc (E)
9	Nuclear Fuel Cycle	10	English	L, E, P	MSc (E)
10	Radiation Safety	10	English	L, E, P	MSc (E)
11	Seminar	10	English	S	MSc (O)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

²Obligatory = O, Elective = E

Leibniz University of Hannover

Institute for Radiation Protection and Radioecology

www.zsr.uni-hannover.de



In the Leibniz University nuclear and radiochemistry can be studied under two MSc programs: MSc in Analytical chemistry (I) and MSc in Mineralogy (II). Curriculum of the first degree includes total 22 ECTS of courses e.g. under topics radioanalytics, radioecology and radiation safety; average 10 students are attending the program annually. The second program has an optional module in radioanalytics and radiation safety (12 ECTS). Furthermore, there is possibility to do PhD studies in NRC, current research projects concerns Uranium and progeny in environmental samples and I-129 in the environment. The department has 5 permanent staff for teaching NRC.

Freie Universität Berlin

Institute of Chemistry and Biochemistry, Inorganic chemistry, Radiochemistry group

<http://www.bcp.fu-berlin.de/chemie/en/ac/agabram/index.html>

At the Frei Universität Berlin basic radiochemistry (7 ECTS) is taught under the degree BSc in Chemistry. At MSc level, 10 ECTS of courses (radiochemistry, radiation protection) and a diploma work (30 ECTS) in NRC related fields can be included in the MSc program in Chemistry. Average 45 students are graduating with this degree annually. A possibility to PhD studies in NRC is also offered; current 3 projects are in the field of Tc-chemistry. Four permanent staff members, 2 PhD students and 2 external lecturers are participating in teaching NRC in the department.

Karlsruhe Institute of Technology, KIT

Fakultät für Chemie und Biowissenschaften

Institute for Nuclear Waste Disposal (INE)

<http://www.kit.edu/kit/english/>

Since October 01, 2009, Universität Karlsruhe has merged with the Forschungszentrum Karlsruhe into the Karlsruhe Institute of Technology (KIT). KIT offer education e.g. in nuclear waste management and radioanalytical chemistry, however, the curricula are not described in recently modified web pages. Moreover, detailed information on the programs was not provided.

Johannes Gutenberg University, Mainz

Department of Chemistry, Pharmacy and Geosciences, Institute of Nuclear Chemistry

<http://www.kernchemie.uni-mainz.de/>

The Institute of Nuclear Chemistry offers a variety of NRC related courses, such as actinides chemistry and radiopharmaceutical chemistry, at diploma level. Education at BSc level has started at 2010; current course offer is based on general nuclear chemistry, taught for BSc students in chemistry. There is no NRC education at MSc level, however, PhD studies can be done under various research fields. Current projects are described in Table 5.9.8. Teaching staff in the department consist of 27 permanent members, 34 PhD students and 2 external lecturers.

Table 5.9.9: Current PhD projects related to NRC in the Johannes Gutenberg University

Research topic	PhD-projects
Development of radiopharmaceuticals for nuclear imaging (PET, SPECT)	5
Development of targets for nuclear physics experiments	4
Mass spectrometry of rare isotopes	5
Laser spectroscopy of actinides and other radionuclides	5
Sorption of actinides on mineral surfaces	3
Chemistry of the heaviest elements	3
Boron neutron capture therapy	2

München University of Technology

Chemistry Department, Institute for Radiochemistry

www.radiochemie.de

At TU Munich, NRC related education is focused on Radioanalytics and Radiopharmacy. Three related courses, i.e. Basic Radiochemistry I, Special aspects of Radiochemistry and Radiochemistry and Radiopharmacy, are offered as elective courses for the BSc or MSc degree in Chemistry, or Nuclear Medicine (last course). In addition, there is possibility to do PhD work in related fields, current research projects are listed in Table 5.9.10. Six permanent staff members and 4 PhD students participate in teaching NRC in the department.

Table 5.9.10: Current PhD projects related to NRC at TU Munich

Research topic	PhD-projects
Nuclear reaction mechanism studies and developments in SHE research	2
Production and separation of the radioisotopes for nuclear medicine	2
Neutron imaging and tomography	1

TU Clausthal

Institute of Disposal Research

<http://www.ielf.tu-clausthal.de/en/ueber-uns/>

TU Clausthal offer a MSc degree MSc in Radioactive and Hazardous Waste Management which contains a minor part applied NRC, such as courses related to radioactive waste management and isotopic geochemistry.

Hochschule Zittau/Görlitz -University of Applied Sciences

Fakultät Mathematik/Naturwissenschaften

By the university web pages, a course module including Applied Nuclear and Radiochemistry, Power Plant Chemistry, Fuel Gas Treatment (10 ECTS) is included in the degree MSc in Chemistry.

5.10 GREECE

In Greece, nuclear and radiochemistry is taught in three universities, Aristotle University in Thessaloniki, University of Patras and National Technical University of Athens.

Aristotle University in Thessaloniki

Department of Chemistry, Laboratory of Inorganic Chemistry

<http://www.chem.auth.gr>

Basic course on NRC is offered both at BSc and MSc level, for students in Chemistry and in Chemistry and Chemical Education, respectively. A diploma work (11 ECTS) in the field of NRC can also be included in both programs. Average number of students attending annually these programs is 40 and 6, respectively. The group also participates in a Post-Graduate Program on Nuclear Technology organized by the Engineering Faculty of the Aristotle University. It covers the field Nuclear Fuel Cycle. Furthermore, there is possibility to do PhD work in radiochemistry; topic of the current two projects is Development and investigation of natural and synthetic sorbents for radionuclides and heavy metals. The department has 2 permanent staff members and 2 PhD students participating in teaching.

University of Patras

Department of Chemistry, Radiochemistry group

<http://www.chem.upatras.gr>

A course entitled Principles and Applications of Nuclear Chemistry (5 ECTS) is offered for BSc students in Chemistry. A diploma work (20 ECTS) can also be done in the field of NRC. The group has also research on NRC related fields, current topics and number of PhD-projects are listed in Table 5.10.1. The radiochemistry group of the University of Patras is run by 3 assistant professors in radiochemistry and 4 PhD students are participating in teaching.

Table 5.10.1: Current PhD projects related to NRC in the University of Patras

Research topic	Number of PhD-projects
Sorption of Radionuclides on low cost sorbents (wastes or agro-industrial by-products)	1
Sorption of Radionuclides on microorganisms	1
Determination of air particulate matter by nuclear techniques.	1
Radioisotopes to study the uptake rate of glucose by free or immobilized cells of microorganisms	1

National Technical University of Athens

School of Chemical Engineering, Laboratory of General Chemistry

<http://www.chemeng.ntua.gr>

Two courses on NRC are offered for chemical engineering students. At BSc level the topic is general radiochemistry, the MSc level course is entitled as Nuclear Chemistry–Nuclear Technology. There is no PhD work in related fields.

5.11 HUNGARY

In Hungary there are several universities/institutions giving education in nuclear and radiochemistry. University of Pannonia offer educational programs in NRC at various levels; individual courses related to NRC are given in Eötvös Lorand University in Budapest, Debrecen University as well as in Budapest University of Technology and Economics.

University of Pannonia

Department of Radiochemistry and Radioecology

<http://radio.mk.uni-pannon.hu>

University of Pannonia offers NRC related education from BSc to PhD level. No specific areas of education are stated, however, majority of the education is given under environmental engineering programs. Complete programs in NRC are described in Table 5.11.1. and detailed information on the course supply is listed in Table 5.11.2. Average 8 students are graduated annually with the BSc degree; both programs at MSc level are new, started at 2009. Furthermore, there are 6 PhD projects under NRC related fields; topics are listed in Table 5.11.3. The department has 5 permanent staff members and 5 PhD students participating in teaching.

Table 5.11.1: NRC related educational programs in the University of Pannonia

Degree/specialization	Courses	Research training (other than diploma work)	Diploma work	ECTS Total (degree total)
BSc in Environmental engineering/ NRC	21	8	10	39 (210)
MSc in Environmental engineering/ NRC	17		30	47 (120)
MSc in Chemical engineering / NRC	26		30	56 (120)

Table 5.11.2: NRC related course supply in the University of Pannonia

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Basics of Radiation	1	Hungarian	L	BSc (O)
2	Radioecology	2	Hungarian	L	BSc (O)
3	Nuclear Energetic	2	Hungarian	L	BSc (E)
4	Natural and artificial radiations <i>Radioecology specialization</i>	2	Hungarian	L	BSc (E)
5	Nuclear Energetic	2	Hungarian	L	BSc (O)
6	Dosimetry and Radiation Protection	2	Hungarian	L	BSc (O)
7	Nuclear emergency management, radioactive waste management	2	Hungarian	L	BSc (O)
8	Nuclear Metrology	2	Hungarian	L	BSc (O)
9	Uses of radioisotopes	2	Hungarian	L	BSc (O)
10	Lessons from the nuclear and radiation accidents	2	Hungarian	L	BSc (O)
11	Radiations and radionuclides in the nature	3	Hungarian	L	BSc (O)
12	Radioecology and Nuclear Metrology <i>Radioecology specialization</i>	6	Hungarian	P	BSc (O)
13	Decontamination in Nuclear Power Plant	2	Hungarian	L	MSc (O)
14	Environmental radiations, radiation protection	2	Hungarian	L	MSc (O)
15	Nuclear chemistry and application of radioisotopes	2	Hungarian	L	MSc (O)
16	Radioactive waste disposal	2	Hungarian	L	MSc (O)
17	Radioactive tracer methods	2	Hungarian	L	MSc (O)
18	Radiation accident management	2	Hungarian	L	MSc (O)
19	Radiation chemistry and technology	2	Hungarian	L	MSc (O)
20	Radiation measurement Radiochemistry specialization	3	Hungarian	P	MSc (O)
21	Nuclear Measurements	4	Hungarian	L,P	MSc (O)
22	Radiation protection, radioactive waste disposal	6	Hungarian	L	MSc (O)
23	Technologies utilized in NPP	8	Hungarian	L,P	MSc (O)
24	Technologies using radioisotopes	8	Hungarian	L	MSc (O)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

Table 5.11.3: NRC related PhD projects in the University of Pannonia

Research topic	PhD-projects
Comparative study of efficiency, surface chemical and corrosion effects of chemical decontamination technologies	2
Towards multipurpose radiotracer methods for the investigation of contamination and corrosion phenomena on constructional material surfaces	1

Determination of the age of sediments by radiometric methods	1
Radiological study of underground spaces, radiological protection of manganese miners	1
Radon and radon daughters	1

Eötvös Lorand University in Budapest

Faculty of Science, Institute of Chemistry

<http://www.chem.elte.hu/en/main>

Based on the web pages of the institute, various NRC related courses are given at MSc level, mainly for students taken the degree MSc in Chemistry with specialization environmental chemistry. Topics of these courses are nuclear chemistry, nuclear methods in materials science and nuclear techniques in structural chemistry. Teaching of NRC is the responsibility of the Department of Analytical Chemistry whereas research is carried out in the Laboratory of Nuclear Chemistry.

Debrecen University

NRC related education is mainly given in the Department of Colloid and Environmental Chemistry (Isotope and Environmental Chemistry Group). Basic radiochemistry (3 ECTS) course is obligatory for BSc studies in chemistry, environmental science and chemical engineering. Basic radiochemistry (2 ECTS, included in obligatory physical chemistry) and radioanalytical chemistry (3 ECTS) courses are offered for MSc students in chemistry. Average 70 students are attending annually the first and average 20 students the second basic course in radiochemistry. Furthermore, there is possibility to do PhD studies in NRC related fields; topic of the current project is Storage of radioactive wastes, interactions of isotopes with the geological formations. Four permanent staff members are participating in teaching NRC in the department.

In addition, at the Institute of Nuclear Research/Department of Environmental Physics a course on radiopharmacy (2 ECTS) is taught for MSc students in Pharmacy. There are also two PhD projects related to radioactive waste management.

Budapest University of Technology and Economics

Faculty of Natural Sciences, Institute of Nuclear Techniques

<http://www.reak.bme.hu/en/home.html>

Based on the web pages of the institute, NRC related courses such as radiochemistry and radiation chemistry are given at MSc level, mainly for physics students under the specialization nuclear techniques.

5.12 ITALY

In Italy, nuclear and radiochemistry can be studied e.g. in the University of Pavia and University of Milan. In addition, at the University of Napoli (Department of Chemistry, <http://chemistry.unina.it:8080/home.html>) students at MSc level can study e.g. Chemistry of radioisotopes.

University of Pavia

General Chemistry

www.unipv.eu

In the University of Pavia courses on basic and advanced radiochemistry (total 6 ECTS) are taught for BSc students in chemistry with average 20 students attending annually. The department has also research on radiochemistry, current PhD-works (3) are related to radiochemical and -analytical methods.

University of Milan

Group of Radiochemistry and Radiation Chemistry

<http://www.lasa.mi.infn.it>

Topics of NRC related courses and current PhD-projects in the University of Milan are listed in Tables 5.12.1. and 5.12.2. The courses are taught once/year for students in physics or chemistry. Diploma work (60 ECTS) in NRC is also possible and average 4 chemistry students at MSc level are graduating annually with this specialization. The Group of Radiochemistry and Radiation Chemistry is a part of L.A.S.A. (Laboratorio Acceleratori e Superconduttività Applicata Interdivisional) and has 8 persons (5 permanent staff) participating in teaching.

Table 5.12.1: NRC related courses in the University of Milan

	Title	Credits	Language	Type ¹	Level
1	Basic Radiochemistry	6	Italian, English	L, E, P	BSc
2	Basic Health Physics	12	Italian, English	L, P	MSc
3	Radiopharmaceutical chemistry	2	Italian, English	L, P	MSc
4	Environmental Radioactivity	2	Italian, English	L, S	MSc

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

Table 5.12.2: Current PhD projects related to NRC in the University of Milan

Research topic	PhD-projects
Development of radiopharmaceuticals for nuclear imaging (PET, SPECT)	1
Development of radiopharmaceuticals for metabolic radiotherapy and imaging	1
Radionuclide production	1

5.13 THE NETHERLANDS

Delft University of Technology

Faculty of Applied Sciences, Department Radiation and Isotopes for Health

<http://www.tudelft.nl/live/pagina.jsp?id=70f9805f-de88-4790-83dc-b5b04db554a6&lang=en>

The MSc program in chemical engineering in Delft University of Technology has currently a specialization in nuclear science and engineering. This program consists of research training (15 ECTS), design project (20 ECTS), diploma work (40 ECTS) and 30 ECTS courses of which nuclear science and nuclear chemistry (total 9 ECTS) are related to NRC and obligatory in the degree. First students (15) will be graduated from this program this year, 2011. Education in the department is focused on NRC for health or energy; research topic is described as Targeted nano-carriers for improved alpha-therapy, currently having one PhD-project. Five external lecturers are participating in teaching with 4 permanent staff members.

5.14 NORWAY

In Norway, two universities offer possibility to specialize in NRC at MSc or PhD level: Norwegian University of Life Sciences in Ås and Oslo University.

Norwegian University of Life Sciences, UMB

Department of Plant and Environmental Sciences, Environmental Chemistry

<http://www.umb.no/ipm-en>

Nuclear and radiochemistry education in the Norwegian University of Life Sciences is focused on radiochemistry, radioecology and radioecotoxicology. The university offers a full MSc degree in radioecology which is accredited with European Master status and is taught completely in English. Furthermore, MSc students in chemistry can specialize in radiochemistry; radiochemistry and radioecology courses are also included in the MSc degree in Environment & natural resources as depicted in Tables 5.14.1. and 2.

The EurMSc program is open for students having environmental related BSc degree, e.g. in chemistry, biology, environmental engineering, and average 10 national and international students are graduating with this degree annually. In addition, average 5 MSc students in chemistry are graduated annually with the specialization in radiochemistry. There are currently 5 PhD projects in the direct field of radiochemistry and radioecology, in addition to 12 projects in environmental chemistry and other topics where radiochemistry (tracer techniques) is used. The key staff in teaching radiochemistry at UMB consists of 9 permanent members. Furthermore, 3 external lecturers and 3 PhD students are participating in teaching.

Table 5.14.1: NRC related educational programs at UMB

Degree / Specialization	Courses	Final exam(s)	Research training	Diploma work	ECTS Total (degree total)
(I) EurMSc in Radioecology	60	(3)		60	120
(II) MSc in Chemistry / Radiochemistry	60-90	(3)		30-60	90 ¹ (120)
(III) MSc Environment and natural resources	60-90			30-90	10-90 ² (120)
PhD in NRC	20-60				20-60 (60)

¹Proportions given for the overall degree, 90 ECTS of NRC should be included in the specialization

²Proportions given for the overall degree, minimum proportion of NRC 10 ECTS of courses

Table 5.14.2: NRC related courses at UMB

	Title	Credits	Language	Type ¹	Target group ² (O/E ³)
1	Basic Radiochemistry	10	English	L, P	MSc I (O)/ II (O)/III (E)
2	Radioecology	10	English	L, P, E	MSc I (O)/II (O)/III (E)
3	Risk assessment	5	English	L, E	MSc I (O)/II (E)/III (E)
4	Ecotoxicology	15	English	L, S	MSc I (E)/II (E)/III (E)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

²As in Table 5.13.1.

³Obligatory = O, Elective = E

University of Oslo, UiO

Department of Chemistry, Centre for Accelerator Based Research and Energy Physics (SAFE), Nuclear Chemistry Group

www.safe.uio.no; <http://www.kjemi.uio.no/english/>

At the University of Oslo NRC can be included in chemistry studies already at BSc level, however, specialization in the field is possible at MSc and PhD level. Programs and course supply are listed in Tables 5.14.3. and 4. In general, the number of students in chemistry has decreased in recent years; therefore, only average 1 student is graduating annually with the specialization in NC. Education (and research) at UiO is focused on following topics: Superheavy elements, Radiopharmaceutical chemistry (PET-related) and Industrial use of radioactivity (tracers, radionuclide generators, etc.), as well as Nuclear Energy Technology (reactors, fuel, reprocessing and disposing spent fuel, use of thorium in the nuclear fuel cycle) in collaboration with the Nuclear Physics group at UiO, Institute for Energy Technology (IFE), and the Norwegian Radiation Protection Authority (NRPA). Current PhD projects under the related topics are listed in Table 5.14.5. The department has 4 permanent staff members and 2 PhD students participating in teaching NRC.

Table 5.14.3: NRC related educational programs at UiO

Degree/specialization	Courses	Final exam(s)	Diploma work	ECTS Total (degree total)
MSc in Chemistry/ Nuclear chemistry	20-40	(1)	60	80-100 (120)
PhD in Nuclear chemistry	30-50	-	130-150	180

Table 5.14.4: NRC related course supply offered by UiO

	Title	Credits	Language	Type ¹	Target group ² (O/E ³)
1	Radioactivity and radiochemistry	10	Norwegian	L, E	BSc (E)
2	Radiochemical methods	10	Norwegian or English	L, E	MSc (O)
3	Laboratory exercises in radiochemistry	10	Norwegian or English	P	MSc (O)
4	Nuclear measurement techniques and instruments	10	Norwegian or English	L, P	MSc and PhD (E)
5	Radiopharmaceutical chemistry	10	Norwegian or English	L, E	MSc and PhD (E)

In addition, the following courses are frequently used as support for a MSc or PhD in Nuclear Chemistry:

6	Nuclear Technology	10	Norwegian or English	L, E	MSc (E)
7	Radiation and radiation measurement	10	Norwegian or English	L, E	MSc (E)
8	Nuclear Physics, structure and spectroscopy	10	Norwegian or English	L,ES	BSc and MSc (E)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² As in Table 5.14.3.

³ Obligatory = O, Elective = E

Table 5.14.5: NRC related PhD projects at UiO

Research topic	PhD-projects
Investigation of chemical properties of transactinide elements with automated liquid-liquid scintillation system SISAK	2
Modelling and simulating the use of thoriated fuel in light water reactor cores	1

5.15 POLAND

In Poland, there are two universities which have educational programs in nuclear and radiochemistry: Maria Curie Sklodowska University in Lublin and University of Gdansk. In

addition, three other universities/institutes, i.e. University of Warsaw, Nicolaus Copernicus University (Torun) and Institute of Nuclear Chemistry and Technology, offer individual courses under various educational programs.

Maria Curie Sklodowska University

Faculty of Chemistry, Department of Radiochemistry and Chemistry of Colloids

<http://radiochemistry.umcs.lublin.pl/home/ZRiChK.htm>

The general education in the department is focused on analytical chemistry and application of computers in chemistry. Basic radiochemistry is taught at BSc level and students can specialize in radiochemistry under the degree MSc in Analytical chemistry. Contents of this new specialization were not provided in detail; however, the overall course supply is listed in Table 5.15.1. In addition, PhD work can be carried out in various fields; current topics are listed in table 5.15.2. Sixteen permanent staff members and 4 PhD students are participating in teaching in the department.

Table 5.15.1: NRC related courses at the Maria Curie Sklodowska University

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Radiochemistry and radioisotopic techniques	5	Polish	L,P	BSc (O)
2	Radioisotopes' methods of analysis	4	Polish	L,P	MSc (O)
3	Radioisotopic techniques	3,5	Polish	L,P	MSc (E)
4	Trace analysis	4	Polish	L,E	MSc (O)
5	Quantitative analysis in organic matrix	4	English	L,E	MSc (O)
6	Biological and Chemical Effects on radiation on living organisms	1	Polish	L	MSc (O)
7	Radiometry and protection against radiation	5	Polish	L,P	MSc (O)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

Table 5.15.2: Current PhD projects related to NRC at the Maria Curie Sklodowska University

Research topic	PhD-projects
Separation of plutonium from uranium and thorium with a use of liquid scintillator	1
Optimization of measurement parameters of chosen isotopes with a use of scintillators	1
Methods of analyzing strontium -90 in water	1
Study on the plutonium migration rate in soils	1
Measurements on the migration of strontium-90 in soils	1

University of Gdansk

Faculty of Chemistry, Analytics and Environmental Radiochemistry Chair

http://www.chem.univ.gda.pl/kars/index_en.html

NRC related education at the University of Gdansk is focused on natural and artificial radiochemistry of marine and land environment. The department offer specialized education both at MSc and PhD level, programs are described in Table 5.15.3 and the overall course offer in Table 5.15.4. Average 7 students are graduated annually with the degree in environmental protection and 2 with general NRC, respectively. There are currently 2 PhD projects under the topics Radiochemistry; Chemical and radiochemical trace analysis (alpha-spectrometry). Eight permanent staff members and 2 PhD students are participating in teaching NRC.

Table 5.15.3: NRC related educational programs in the University of Gdansk

Degree/specialization	Courses and seminars	Research training (other than diploma work)	Diploma work	ECTS Total (degree total)
(I) MSc in Environmental protection/ Radiochemistry	20	3	50	73 (120)
(II) MSc in Chemistry/ Nuclear and radiochemistry	20	3	30	53 (120)
PhD in Chemistry / NRC			10	

Table 5.15.4: NRC related courses in the University of Gdansk

Title	Credits	Language	Type ¹	Target group ² (O/E ³)
1 Chemical and radiochemical trace analysis	4	Polish	L, E, P	MSc I (O)
2 Nuclear medicine	1	Polish	L	PhD (E)
3 Nuclear chemistry and radiochemistry	2	Polish	L	MSc II (E)
4 Radioactive contamination of environment	2	Polish	L	MSc (E)
5 Environmental radiochemistry and radiological protection	2	Polish	L	MSc (E)
6 Marine radiochemistry	4	Polish	L, E	MSc I (E)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² As in Table 5.14.3.

³ Obligatory = O, Elective = E

University of Warsaw

Faculty of Chemistry, Division of Physics and Radiochemistry, Laboratory of Radiochemistry
www.chem.uw.edu.pl/index_en.php

In the University of Warsaw courses on general and applied NRC are taught both at BSc and MSc level for students in chemistry, see Table 5.15.5. At BSc level average 50 students are attending the courses annually, at MSc level the number is much lower, 5. Furthermore, there are 4 PhDs project under the topics Development of radiopharmaceuticals for nuclear imaging and Isotope effects on phase equilibria. The teaching staffs consist of 12 permanent members and 4 PhD students.

Table 5.15.5: NRC related courses in the University of Warsaw

Title	Credits	Language	Type ¹	Target group (O/E ²)
1 Nuclear Chemistry I	2	Polish	L	BSc (E)
2 Nuclear Chemistry I	2	Polish	E	BSc (E)
3 Nuclear Chemistry II	8	Polish	E	MSc (E)
4 Nuclear Chemistry	2	Polish	S	MSc (E)
5 Nuclear energy and radioactivity	2	Polish	L	MSc (E)
6 Radiopharmaceutical synthesis and its application in medicine	2	Polish	L	MSc (E)
7 Isotope Effects	2	Polish	L	MSc (E)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

Nicolaus Copernicus University (Torun)

Faculty of Chemistry, Department of Nuclear Chemistry

<http://www.chem.umk.pl/Faculty-of-Chemistry.html>

Based on the university web pages chemistry students both at BSc and MSc level can include in their studies course on nuclear chemistry.

Institute of Nuclear Chemistry and Technology

www.ichtj.waw.pl

NRC related education at the Institute of Nuclear Chemistry and Technology is given under 2 departments: Centre for Radiochemistry and Nuclear Chemistry and Laboratory of Nuclear Analytical Methods. The education is aimed at PhD students and is mainly research based; at MSc level there is one course on Coordination chemistry (radionuclide separation and radiopharm. aspects). Topics of the current research projects are listed in Table 5.15.6. The key staffs in teaching consist of 5 permanent staff members.

Table 5.15.6: NRC related PhD projects at the Institute of Nuclear Chemistry and Technology

Research topic	PhD-projects
Development of diagnostic (PET, SPECT) and therapeutic radiopharmaceuticals	6
Elements of nuclear fuel cycle – materials, separation methods/technologies	4
Reprocessing of liquid radioactive waste	2
Environmental radiochemistry and nuclear analytical methods	2

5.16 SLOVAKIA

In Slovakia, education in NRC is mainly given in Comenius University in Bratislava. In addition, some related courses, i.e. radioecology and nuclear analytical methods, are offered for environmental engineering students in the Technical University of Zvolen (Faculty of Ecology and Environmental Sciences, Department of Environmental Engineering, <http://www.tuzvo.sk/en>).

Comenius University

Faculty of Natural Sciences, Department of Nuclear Chemistry

<http://www.fns.uniba.sk/index.php?id=2389>

At the Comenius University nuclear and radiochemistry can be studied from BSc to PhD level, NRC related curricula and course supply are described in Tables 5.16.1. and 2. Average 5 students are graduated annually with the MSc degree. The current 4 PhD projects are in the fields of Development of radiopharmaceuticals for nuclear imaging (PET, SPECT) and Determination of radionuclides in environmental and NPP samples. The department has 7 permanent staff members participating in teaching NRC.

5.16.1. NRC related educational programs at the Comenius University

Degree	Courses and seminars	Final exam(s)	Research training (other than diploma work)	Diploma work	ECTS Total (degree total)
MSc in chemistry/ Nuclear Chemistry and Radioecology	57		14	29	100 (120)
PhD in Chemistry/ Nuclear Chemistry	24	45	109	40	218 (240)

5.16.2. NRC related courses at the Comenius University

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Basic Radiochemistry I	5	Slovak	L, S, P	BSc (O)
2	Basic Radiochemistry II	2	Slovak	L,	BSc (E)
3	Radiolabeled chemistry	6	Slovak	L,	MSc (O)
4	Environmental Radioactivity	3	Slovak	L,	MSc (O)

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

5.17 SLOVENIA

Josef Stefan International Postgraduate school, Ljubljana

<http://www.mps.si/splet/index.asp?lang=eng>

Based on the available information in the internet, Josef Stefan International Postgraduate school offers courses on radioecology, radioactive and nuclear methods for the study of processes under MSc and PhD in Ecotechnology. The school has collaboration with J Stefan Institute (Group for Radioecology, <http://en.environment.si/section-structure/group-for-radioecology>), University of Nova Gorica, University of Ljubljana and University of Primorska.

5.18 SPAIN

Majority of the Spanish universities, especially technical universities are involved in nuclear engineering and technology programs. Moreover, a lot of NRC related education and research is carried out under nuclear physics departments. Based on internet survey radiochemistry courses are found in MSc studies for chemistry in the University of Barcelona (Faculty of Physics and Chemistry, Department of Analytical Chemistry, http://www.ub.es/dqa/eng/index_eng.html) and University of Granada (Faculty of Science, Department of Inorganic Chemistry, <http://qiserver.ugr.es/asignaturas.html>).

5.19 SWEDEN

Two universities in Sweden are currently offering education in nuclear and radiochemistry: Chalmers University of Technology and KTH Royal Institute of Technology. Furthermore, a biomedical program MSc in Medical Nuclide Techniques including some radiochemistry is given at the Uppsala University (<http://www.uu.se/en/node605?pKod=MMN2M&lasar=10%2F11>).

Chalmers University of Technology

Department of Chemical and Biological Engineering / Nuclear Chemistry

<http://www.chalmers.se/chem/EN/divisions/nuclear-chemistry>

Chalmers University of Technology has a specialization in Nuclear chemistry under two different MSc programs as depicted in Table 5.19.1. New courses in the fields of radiopharmaceutical chemistry and radioecology have been included in the curriculum (from 2010), especially for the MSc students in chemistry and biosciences, see Table 5.19.2. Both MSc programs are taught fully in English and have average 20 students attending annually. Furthermore, specialization in Nuclear chemistry, e.g. in actinide chemistry, is possible at PhD level; topics of the current research fields are listed in Table 5.19.3. The key staffs in teaching NRC consist of 6 permanent staff members. Furthermore, 10 PhD students are participating in teaching.

Table 5.19.1: NRC related educational programs at Chalmers University of Technology

Degree/specialization	Courses	Research training (other than diploma work)	Diploma work	ECTS Total (degree total)
(I) MSc in Nuclear Engineering/ Nuclear chemistry	45		30	75 (120)
(II) MSc in Chemistry and Biosciences/ Nuclear Chemistry	15		30	45 (120)
PhD in Nuclear Chemistry				60 (60)

Table 5.19.2: NRC related courses at Chalmers University of Technology

	Title	Credits	Language	Type ¹	Level
1	Nuclear Chemistry	7.5	English	L, P	MSc
2	Applied Nuclear Chemistry	7.5	English	L, P	MSc
3	Chemistry of Lanthanides, Actinides and Super-heavy Elements	7.5	English	L, P	MSc
4	Solvent Extraction	7.5	English	L, P	MSc
5	Radiopharmaceutical chemistry	7.5	English	L, P	MSc
6	Radioecology and Radioanalytical Chemistry	7.5	English	L, P	MSc

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

Table 5.19.3: Current PhD projects related to NRC at Chalmers University of Technology

Research topic	PhD-projects
Separation for transmutation	3
Severe reactor accidents	2
Final storage of radioactive waste	1
Ra/Ba chemistry	1

KTH Royal Institute of Technology

The School of Chemical Science and Engineering, Department of Chemistry, Nuclear Chemistry
http://www.kth.se/che/divisions/nuchem/valkommen-till-karnkemi-pa-kth-1.16841?l=en_UK

At KTH education is focused on radiation chemistry and chemical problems in connection to deep repositories for spent nuclear fuel (including actinide chemistry) and reactor chemistry. Students with chemistry background can include courses in NRC (reactor chemistry, nuclear fuel cycle, photo-, -radiation and radical chemistry, total 22.5 ECTS) and do a diploma work (30 ECTS) in NRC related fields under the degrees of MSc in Chemical engineering or MSc in Molecular Science and Engineering (120 ECTS). Average 30 students are graduated annually with this “specialization”. Furthermore, there is a possibility to do PhD studies in NRC related fields, current projects are listed in Table 5.19.4. The department has 3 permanent staff members and 2 PhD students participating in teaching NRC.

Table 5.19.4: Current PhD projects at KTH

Research topic	PhD-projects
Interfacial Radiation Chemistry (Nuclear Fuel and Reactor Chemistry)	3
Colloid facilitated radionuclide migration	2
Photocatalytic purification of water	1

5.20 SWITZERLAND

University of Bern, University of Zürich and Technical University of Zürich (ETHZ) offer NRC related education in Switzerland. Furthermore, both the University of Bern and ETHZ has close collaboration with Paul Scherrer Institute (PSI) i.e. joint courses are organized and students can do their diploma work at both institutes.

University of Bern (collaboration with Paul Scherrer Institute, PSI)

Department of Chemistry and Biochemistry, Radiochemistry Group

http://www.dcb.unibe.ch/content/index_eng.html

NRC related courses (and courses containing some NRC) in the University of Bern are listed in Table 5.20.1. At BSc level education is aimed at students in chemistry, biochemistry and pharmacy. Average 15 students are attending each BSc course annually, but in the basic course the number of attendants is as high as 140. A variety of courses is also offered for an MSc degree in Chemistry and biosciences (90 ECTS). The program is research-based containing 45 ECTS of courses and 45 ECTS for the diploma work. Average 10 students attend the program annually. Furthermore, there is possibility to do PhD studies under various fields of NRC; topics of the current projects are listed in Table 5.20.2. Education is organised in close collaboration with the Department of Biology and Chemistry at PSI. Total nine permanent staff members and 18 PhD students are participating in teaching.

Table 5.20.1: NRC related courses in the University of Bern

	Title	Credits	Language	Type ¹	Target group (O/E ²)
1	Allgemeine Chemie (Einführung Radioaktivität); 4 hours NRC	4	German	L/E	BSc (O)
2	Instrumentalanalytik II; 16 hours NRC	3	German	L/E	BSc (O)
3	Physikalische Chemie IV; 16 hours NRC	3.75	German	L/E	BSc (O)
4	Biochemische Methoden I; 9 hours NRC	3	German	L/E	BSc (O)
5	Nuclear- and Radiochemistry	3	German /English	L/E	MSc (E)
6	Atmospheric and Aerosol Chemistry	3	German /English	L/E	MSc (E)
7	Environmental Chemistry	3	German /English	L/E	MSc (E)
8	Lab Course Nuclear and Radiochemistry	4	German	P	BSc (E)
9	Summer Lab Course (PSI)	4	German	P	MSc (E)
10	Kolloquium Radio- und Umweltchemie		German/English	S	MSc/PhD
11	Course Atmospheric Interface Chemistry (ETHZ)	3	German/English	L/E	MSc

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

² Obligatory = O, Elective = E

PSI= Paul Scherrer Institute, ETHZ=Die Eidgenössische Technische Hochschule Zürich

5.20.2. Current PhD projects in the University of Bern

Research topic	PhD-projects
Development of radionuclides for therapy	1

Superheavy element chemistry	2
Environmental radionuclides	2
Atmospheric chemistry / Surface chemistry	4
Analytical chemistry/ Paleo-climate research	6
Rad-Waste Analytics	3

Information on the other two universities is mainly based on their web pages. At the **University of Zürich** (Institute of Inorganic Chemistry, <http://www.aci.uzh.ch/>) radiochemistry course(s) are taught under the degree MSc in Chemistry with specialization inorganic chemistry. The **Technical University of Zürich** (Die Eidgenössische Technische Hochschule Zürich, ETHZ, Swiss Federal Institute of Technology) is involved in e.g. radiopharmaceutical chemistry education. The Institute of Pharmaceutical Sciences (<http://zrw.web.psi.ch/>) offer course(s) in radiopharmaceutical chemistry and a course module is organized for the European specialization certificate in radiopharmacy. The Institute is sponsored by ETHZ, PSI and the University Hospital in Zürich.

5.21 TURKEY

At **Ege University** in Izmir (Faculty of Sciences, Department of Chemistry) NRC education, i.e. courses and possibility to do a diploma work in the field of nuclear chemistry, is offered from BSc to PhD level. Details of the course offer by the Division of Nuclear Chemistry are described in Table 5.21.1. In addition, education (MSc, PhD-level) and training in NRC is given by the Institute of Nuclear Sciences (<http://nbe.ege.edu.tr/en/>).

Table 5.21.1: NRC related courses at Ege University, Division of Nuclear Chemistry

	Title	Credits	Level
1	Basic nuclear chemistry		BSc (obligatory, BSc in chemistry)
2	Nuclear chemistry I		BSc (elective)
3	Nuclear Chemistry II		BSc (elective)
4	Advanced nuclear chemistry I	4	MSc
5	Radiochemistry and its applications	4	MSc
6	Specific field course	3	MSc
7	Radioation chemistry and its applications	4	MSc
8	Specific field course	3	MSc
9	Specific topics in nuclear chemistry	5	PhD
10	Specific topics in physical chemistry	4	PhD
11	Specific field course	3	PhD
12	Advanced nuclear chemistry II	4.5	PhD
13	Specific topics in nuclear chemistry II	5	PhD
14	Specific field course	3	PhD

NRC is also taught at two universities in Ankara, **Bilkent University** (<http://curie.chem.metu.edu.tr/>) and **Middle East Technical University METU** (<http://www.fen.bilkent.edu.tr/~cvchem/>). According to the web pages of these departments basic nuclear chemistry is offered mainly as BSc level courses (at METU also higher level) for students under various educational programs. In addition, nuclear technology and engineering programs are found in other universities such as Istanbul Technical University and Hacettepe University in Ankara.

5.22 UK

A number of universities in UK have Nuclear engineering and technology related programs (see details *e.g.* from <http://www.nuclearliaison.com/nl-courses>). General or specialized nuclear or radiochemistry education is currently given in few universities.

University of Loughborough

Department of Chemistry, Environmental Radiochemistry Group

<http://www.lboro.ac.uk/departments/cm/>

NRC related education is offered at undergraduate level *i.e.* under the degrees of BSc (3 years) and MChem (4 years) in Chemical Sciences, as well as under the follow-up MSc degree (1 year) in Chemical Sciences. Topics of the courses are listed in Table 5.22.1. Average number of students graduating annually from the BSc and MSc programs is 75 and 40, respectively. Research and current PhD projects (8) are focused on Chemistry of nuclear waste disposal and Method development for ion radioanalyses. Two permanent staff members in the department are participating in teaching NRC.

Table 5.22.1: NRC related courses in the University of Loughborough

Title	Credits	Language	Type ¹	Target group
Basic Radiochemistry I	10	English	L, E, P,S	BSc, MChem and MSc
Radiation and Nuclear Chemistry	10	English	L, ,E,S	BSc and MChem
Environmental Radiochemistry	10	English	L, E,S	BSc and MChem

¹ Lectures = L, Exercises = E, Laboratory exercises = P, Seminars = S

University of Manchester

School of Chemistry / Nuclear First Training Centre

<http://www.chemistry.manchester.ac.uk/>

The University of Manchester has two departments under which education in NRC is given. The School of Chemistry offers general radiochemistry course module (20 credits) for undergraduate students in chemistry (MChem degree). The course consists of parts The Atomic Nucleus, Origin of the Elements and Actinide Chemistry, and approximately 100 students are taking this course in their final year of studies. Furthermore, there are 13 PhD projects under the topics Coordination chemistry of the radioactive elements, Chemistry of radioactive wastes and Environmental radiochemistry. Three permanent staff members are participating in teaching NRC. These staff members are also involved in teaching at the **Nuclear First Training Centre** which offers a broad variety of NRC related courses at PhD level; topics are listed in Table 5.22.2. In addition to the research topics in the School of Chemistry, there are PhD projects under Synthetic Radiochemistry of the actinides, Chemical Modeling, Geological disposal and Fuel and reactor systems.

Table 5.22.2: Course supply at the Nuclear First Training Centre of the Manchester University

	Title	Credits	Language	Type ¹	Target group ² (O/E ³)
1	Basic Nuclear Physics	5	English	E, P	Ph D (O)
2	Basic Radiochemistry	5	English	E, P	Ph D (O)
3	Overview of Nuclear Fuel Cycle	5	English	L, E	Ph D (O)
4	Basic Nuclear Engineering	5	English	L, E	Ph D (O)
5	Environmental Radiochemistry	7.5	English	E, P	Ph D (O)

6	Materials Science in Nuclear Fuel Cycle	5	English	L, P	Ph D (O)
7	Nuclear Fuels	5	English	L, E	Ph D (O)
8	Radiation Chemistry Effects	5	English	L, E	Ph D (O)
9	Radioactive waste	5	English	L, E, P	Ph D (O)
10	Waste immobilisation, Transport and Migration of Pollutants	7.5	English	L, E, P	Ph D (O)
11	Modelling	5	English	E, P	Ph D (O)
12	Short Research project 1	45	English	E, P, S	Ph D (O)
	Short Research project 2	45			

King's College London

School of Medicine

A one-year (12 months) MSc degree (90 ECTS) in Radiopharmaceutics & PET Radiochemistry is offered in collaboration with the industry (Cancer Research UK, GE Healthcare, Tyco, Siemens Medical, Imaging Equipment Ltd and the Engineering and Physical Sciences Research Council).

6 CONCLUSIONS

Current university curricula in nuclear and radiochemistry (NRC) in Europe were surveyed; 22 countries and 69 universities were eventually included in the study. Majority of these universities have NRC education both at BSc and MSc level; in addition, PhD work under related fields is possible. Total 247 PhD projects were described in the 42 filled questionnaires.

At BSc level NRC is mainly taught in basic courses under various educational programs such as chemistry or environmental sciences. The number of students attending these courses is relatively high, average 40 in each course. There are only few complete programs i.e. BSc/MSc degrees in NRC; however, education in the same extent can be attained in various specializations under e.g. the degrees MSc in Chemistry or Chemical/Environmental engineering. Research training and diploma work have a strong role in specialization, though the extent of specialization varies in different educational systems.

Altogether, 44 educational programs (degree and/or specialization) in 30 different universities were described. However, average number of students graduating annually from these programs is typically 5 or even less. Majority of the specializations are under general nuclear and/or radiochemistry, large specified topic is environmental radiochemistry and/or radioecology. In general, curriculum in NRC reflects research interests of the department. Various form education in NRC and estimation of the total number of students are summarized in Table 6.1.

Table 6.1: Summary of various forms of education in nuclear and radiochemistry in European universities

Type of education	Number of programs	Number of students
Program in NRC at BSc level	8	20-90 ²
* <i>degree in NRC</i>	2	
* <i>specialization¹ in NRC</i>	6	
Program in NRC at MSc level	36	100-250 ²
* <i>degree in NRC</i>	8	
* <i>specialization¹ in NRC</i>	28	

¹ A major subject or a course module plus a diploma work under other program such as BSc or MSc in Chemistry

² Graduating from the programs annually; estimated by the available information in the filled questionnaires and by the total number of programs

As this report is based on the available information on various curricula, mostly relying on the data that was provided with filled questionnaires, it will open for revision when additional or more detailed information is received.

Appendix 1.

LIST OF UNIVERSITIES (/INSTITUTES) GIVING EDUCATION ON NUCLEAR AND RADIOCHEMISTRY IN EUROPE –contact information

Listed countries:

	page		page
AUSTRIA	55	ITALY	63
BELGIUM	55	THE NETHERLANDS	64
BULGARIA	56	NORWAY	64
CROATIA	56	POLAND	65
CYPRUS	56	SLOVAKIA	66
CZECH REPUBLIC	57	SLOVENIA	66
FINLAND	58	SPAIN	66
FRANCE	58	SWEDEN	67
GERMANY	60	SWITZERLAND	67
GREECE	62	TURKEY	68
HUNGARY	62	UK	68

AUSTRIA

	<i>NRC course(s) under other educational programme(s)</i>	<i>Level</i>
<p>UNIVERSITY OF VIENNA Faculty of Chemistry, Institute of Inorganic Chemistry, Radiochemistry group Head of the Department / Group B.K.Keppler / Gabriele Wallner Web pages http://anorg-chemie.univie.ac.at Tel. +43 1 427752622 Fax. +43 1 42779526 Postal address Währingerstr. 42, A-1090 Vienna, Austria Contact person: Ass. Prof. Gabriele Wallner gabriele.wallner@univie.ac.at</p>	<p>radiochemistry, radiopharmaceutical chemistry, actinides chemistry = 17 credits</p>	<p>MSc</p>
<p>VIENNA UNIVERSITY OF TECHNOLOGY Faculty of Physics, The Institute of Atomic and Subatomic Physics, Radiation Physics (Radio and Nuclear Chemistry Groups) Head of the Department / Group Christina Strelj / Radiation Physics Web pages http://www.ati.ac.at/index.php?id=16&L=1 Tel. +43 1 58801 14101 Fax. +43 1 58801 14199 Postal address Stadionallee 2 1020 Vienna Austria Contact person: Prof. Max Bichler bichler@ati.ac.at</p>	<p>radiochemistry, environmental INAA = 21 credits</p>	<p>MSc</p>
<p>UNIVERSITY OF INNSBRUCK Faculty of Chemistry and Pharmacy, Institute of Analytical chemistry and Radiochemistry http://www.uibk.ac.at/acrc/ Contact person: Prof. Günther K. Bonn Guenther.Bonn@uibk.ac.at</p>	<p>radiochemistry/radioanalytics = 2.5 credits</p>	<p>BSc</p>
<p>BELGIUM</p>		
<p><i>Dedicated NRC programme(s)</i></p>		
<p>XIOS HOGESCHOOL LIMBURG Department of Industrial Sciences and Technology – Engineering http://www.xios.be/ Contact person: Mr. Francis Vos francis.vos@xios.be</p>	<p>BSc (<i>total 180 credits</i>) and MSc in Nuclear Engineering (Industrial Engineer, <i>total 60 credits</i>), specializations: ➤ environmental technology – radiochemistry ➤ nuclear technology - medical nuclear technology</p>	
	<i>NRC course(s) under other educational programme(s)</i>	<i>Level</i>

GHENT UNIVERSITY

Faculty of Sciences, Department of Analytical Chemistry
<http://www.analchem.ugent.be>
Head of the Department / Group Karel Strijckmans
Web pages www.analchem.ugent.be
Tel. + 32 9 264 48 14
Fax. + 32 9 264 49 60
Postal address Krijgslaan 281 S12
9000 GENT, Belgium
Contact person: Prof. Karel Strijckmans Karel.Strijckmans@UGent.be

radiochemistry = 6 credits BSc

BULGARIA

Dedicated NRC programme(s)

SOFIA UNIVERSITY ST. KLIMENT OHRIDSKI

Faculty of Chemistry, Department of Analytical Chemistry
<http://www.chem.uni-sofia.bg/depart/achem/default.htm>
Head of the Department / Group Prof. Dr. Rumyana Djingova – Kostadinova, DSc
Web pages www.chem.uni-sofia.bg
Tel. ++3592 8161298
Postal address 1, J. Bouchier blvd., 1164 Sofia, Bulgaria
Contact person: Prof. Rumyana Dzgingova
Rdjingova@chem.uni-sofia.bg

1) BSc in nuclear chemistry = 97 credits
NRC of total 240 credits
2) MSc in nuclear chemistry (begins 2010) = 60/60 credits
3) MSc in radiochemistry and radioecology = 90/90 credits
4) PhD in radiochemistry = 175/180 credits
*for other students radioanalytical chemistry and radioecology at BSc level

PLOVDIV UNIVERSITY “Paisii Hilendarski”

Faculty of Chemistry
<http://en.argon.uni-plovdiv.bg/>
Head of the Department/Group: Assoc.Prof. Iliyan Ivanov
Web pages www.uni-plovdiv.bg
Tel. +35932261403
Postal address 24, ‘Tsar Assen’, Str, 4000 Plovdiv, Bulgaria
Contact person: Assoc. Prof. Violeta Milenkova Stefanova, PhD
vstef@uni-plovdiv.bg

1) MSc in radiochemistry and radioecology

CROATIA

NRC course(s) under other educational programme(s) Level

UNIVERSITY OF ZAGREB

Faculty of Science and Mathematics, Section Chemistry
<http://www.chem.pmf.hr/>
Head of the Department / Group Dean of the Faculty of Science: Professor Mladen Juracic
Web pages www.pmf.hr
Tel. 385 (0)1 4606 010
Fax. 385 (0)1 4606 013
Postal address Horvatovac 102A, 10000 Zagreb, Croatia
Contact person: Dr. Dusan Razem
razem@rudjer.irb.hr

basic radiochemistry, radiation chemistry MSc

CYPRUS

NRC course(s) under other educational programme(s) Level

UNIVERSITY OF CYPRUS, Nicosia

Department of Chemistry
 Head of the Group Ioannis Pashalidis
 Web pages <http://www.ucy.ac.cy/goto/chemistry/en-US/HOME.aspx>
 Tel. +357 22 892785
 Fax. +357 22 892801
 Postal address. 75 Kalipoleos Av., 1678 Nicosia, Cyprus
 Contact person: Assoc. Prof. Ioannis Pashalidis
pspasch@ucy.ac.cy

basic radiochemistry, BSc,
 environmental radioactivity = 7 MSc
 credits

CZECH REPUBLIC

Dedicated NRC programme(s)

CZECH TECHNICAL UNIVERSITY IN PRAGUE (CTU)

Faculty of Nuclear Sciences and Physical Engineering
 Department of Nuclear Chemistry
 Head of the Department / Group prof. Jan John
 Web pages www.fjfi.cvut.cz/kjch, www.cvut.cz
 Tel. +420 224 358 228
 Fax. +420 224
 Postal address Břehová 7, 115 19 Prague 1, Czech Republic
 Contact person: Prof. Jan John
jan.john@fjfi.cvut.cz

- 1) BSc in nuclear chemical engineering = 36 credits NRC of total 180 credits
- 2) MSc in nuclear chemical engineering, specializations:
 - applied nuclear chemistry
 - chemistry of the environment
 - nuclear chemistry in biology and medicine
 = 110/144 credits NRC of total 120 (2 years) or 180 credits (3 years)
- 3) PhD in nuclear chemistry

CHARLES UNIVERSITY, Prague in collaboration with CTU
 Faculty of Science, Department of Organic and Nuclear Chemistry
<http://web.natur.cuni.cz/www/en/index.php>
 Head of the Department / Group Prof. Martin Kotora/Asoc. Prof. Ladislav Lešetický
 Web pages www.natur.cuni.cz
 Tel. +420-221951339 (L.L.)
 Fax. +420-221951326 (secretary)
 Postal address Hlavova 8, 12840 Praha 2
 Contact person: Assoc. Prof. Ladislav Lešetický
lesetic@natur.cuni.cz

- 1) MSc in chemistry: specialization nuclear chemistry (radiopharmaceutical chemistry) = 100 credits of total 120 credits
 - 2) PhD in organic chemistry, specialization NRC
- * basic radiochemistry also at BSc level

NRC course(s) under other educational programme(s) Level

MASARYK UNIVERSITY, Brno

Faculty of Science, Department of Chemistry
<http://www.sci.muni.cz/main.php?stranka=31&podtext=&jazyk=EN>
 Head of the Department / Group Dr. Ctibor Mazal
 Web pages www.sci.muni.cz
 Tel. +420549495801
 Fax. -420549492443
 Postal address Kotlářská 2, 61137 Brno
 Czech Republic
 Contact person: Prof.RNDr. Jiří Příhoda jiriprihoda@seznam.cz

radiochemistry, environmental BSc,
 radioactivity = 11 credits MSc,
 PhD

INSTITUTE OF CHEMICAL TECHNOLOGY PRAGUE (ICTP)

<http://www.vscht.cz/homepage/english/main/university/faculties>

a) Faculty of Chemical Engineering, Department of Analytical Chemistry
Head of the Department / Group prof. Štěpán Urban, MSc, PhD
Web pages <http://www.vscht.cz/anl/>
Tel. 220 444 043
Fax. 220 444 352
Postal address Technická 5, 166 28 Praha 6 – Dejvice
Contact person: Dr. Jan Fahnrich jan.fahnrich@vscht.cz

nuclear analytical chemistry =
6 credits

MSc

b) Faculty of Environmental Technology, Department of Power engineering

radioactive waste management,
technical nuclear chemistry

UNIVERSITY OF DEFENCE, Brno

NBC Defence Institute
Head of the Department / Group Col. Prof. Dusan Vicar, Ph.D. / Assoc.
Prof. Petr Sladek, Ph.D.
<http://www.vojenskaskola.cz/school/ud/nbcdi/Pages/default.aspx>
Tel. +420 973 452 301
Fax.
Postal address NBC Defence Institute
Vita Nejedleho
68201 Vyskov, Czech Republic
Contact person: Assistant Jiří Janda
jiri.janda@unob.cz

nuclear chemistry = 4 credits

BSc

FINLAND

Dedicated NRC programme(s)

UNIVERSITY OF HELSINKI

Faculty of Mathematics and Natural Sciences, Department of Chemistry,
Laboratory of Radiochemistry
Head of the Department Professor Jukka Lehto
Web pages <http://www.helsinki.fi/kemia/radiokemia/english>
Tel. + 358 9 191 50 141
Fax. + 358 9 191 50 121
Postal address P.O. Box 55 (A.I.Virtasen aukio 1)
FI-00014 University of Helsinki, Finland
Contact person: Prof. Jukka Lehto
jukka.lehto@helsinki.fi

1) MSc in chemistry: specialization
radiochemistry = 83-84 NRC of total 120
credits
2) PhD in chemistry: specialization
radiochemistry = 50/60 credits
* basic radiochemistry also at BSc level

*NRC course(s) under other
educational programme(s)*

Level

UNIVERSITY OF TURKU

Faculty of Mathematics and Natural Sciences, Department of Chemistry
<http://www.sci.utu.fi/kemia/en/>
Contact person: Prof. Olof Solin
olof.solin@utu.fi

basic radiochemistry, chemistry
of PET-radiopharmaceuticals,
radiochemical measuring
techniques = 16 credits

MSc

FRANCE

Joint programmes related to NRC

Consortium I: ParisTech (<http://www.paristech.fr/>: Ecole Polytechnique
ParisTech – Mines ParisTech – Ecole des Ponts ParisTech – Arts et Métiers
ParisTech – ENSTA ParisTech – Chimie ParisTech) **Université Paris Sud
(XI), Ecole Centrale Paris (ECP), Supelec, l'Institut National des
Sciences et Techniques Nucléaires de Saclay (INSTN)**
<http://www.master-nuclear-energy.fr/en/index.php>

1) MSc Nuclear Energy;
specialization nuclear fuel
cycle

MSc

Consortium II: Université Paris Sud (XI), Université Paris XII, Chimie ParisTech, Mines ParisTech, Polytechnique ParisTech, ECP, INSTN
<http://www.enscp.fr/spip.php?rubrique148>

2) MSc Science of Materials; specialization materials for energy (*Matériaux pour les structures et l'énergie*) MSc

Consortium III: University Montpellier 2, l'Ecole Nationale Supérieure de Chimie de Montpellier (ENSCM), INSTN
<http://www.master-chimie.univ-montp2.fr/CSMP> ;
<http://www-instn.cea.fr/-Chimie-separative-materiaux-et-.html?lang=fr>

3) MSc Sciences, Technology, Health – chemistry and applications; specialization separation chemistry, materials, methods (*Chimie Séparative, Matériaux, Procédés*) MSc

PARIS SUD UNIVERSITY XI

Radiochemistry Group http://www.dep-chimie.u-psud.fr/index.php?option=com_wrapper&view=wrapper&Itemid=169
 Tel. 33169157343
 Fax. 33169157150
 Postal address Paris sud 11 university
 91406 Orsay, France
 Contact person: Prof. Eric Simoni simoni@ipno.in2p3.fr

Programme 1: *profile radiochemistry* MSc
 Programme 2

CHIMIE PARISTECH (École nationale supérieure de chimie de Paris)

Nuclear Science Division <http://www.chimie-paristech.fr/spip.php?page=english>
 Tel. +33 1 56 81 30 56
 Fax. +33 1 56 81 30 59
 Postal address 11, rue Pierre et Marie Curie, 75005 PARIS, France
 Contact person: Prof. Gérard Cote gerard-cote@chimie-paristech.fr

Programme 1: *profile fuel cycle engineering* MSc
 Programme 2
 *radioactivity also at BSc level

UNIVERSITY MONTPELLIER 2

Institute of Separative Chemistry of Marcoule (in collaboration with Commissariat à l'Energie Atomique CEA, Centre national de la recherche scientifique CNRS)
<http://www.master-chimie.univ-montp2.fr/CSMP>
 Contact person: Prof. Nicolas Dacheux nicolas.dacheux@icsm.fr ;
nicolas.dacheux@univ-montp2.fr

Programme 3(*application au cycle du combustible nucléaire ,CSMP*) MSc

l'Ecole Nationale Supérieure de Chimie de Montpellier (ENSCM)

Institute of Separative Chemistry of Marcoule
http://www.icsm.fr/index.php?pagendx=app_1838&project=icsm_engl
 Contact person: Ass. Prof. Luc Girard luc.girard@enscm.fr

Programme 3(*application au cycle du combustible nucléaire ,CSMP*) MSc

École des Mines of Nantes

<http://www.mines-nantes.fr/fr/Formations/Masters-of-Science/SNEWM-ANWM>
 Laboratory of Subatomic Physics and Associated Technologies (SUBATECH, in collaboration with University of Nantes and CNRS),
 Laboratory of radiochemistry
<http://www-subatech.in2p3.fr/~rchimie/index.html>

MSc in Advanced Nuclear Waste Management (*approx. 80 credits NRC of total 120 credits*) MSc

Contact person: Prof. Bernd Grambow grambow@subatech.in2p3.fr

GRENOBLE INP Phelma in collaboration with EDF and CEA - INSTN

Institut Polytechnique Grenoble
Science et Ingénierie des Matériaux et Procédés (SIMAP)
<http://phelma.grenoble-inp.fr/courses/international-master-manuen-materials-for-nuclear-energy-278507.kjsp?RH=1268753006722>
Contact person : Prof. Yves Brechet ybrechet@simap.grenoble-inp.fr

Master international MaNuEn -
Materials for nuclear energy –
qualification (*Total 11 credits*),
as separate courses for PhD
studies

***NRC course(s) under other
educational programme(s)*** ***Level***

UNIVERSITY OF NICE-SOPHIA ANTIPOLIS (Université de Nice-Sophia)

Institute of Chemistry, Laboratoire de Radiochimie, Sciences Analytiques et Environnement <http://unice.fr/>
<http://portail.unice.fr/jahia/Jahia/site/myjahiasite/pid/936>
Contact person: Prof. Geneviève Barci genevieve.barci@unice.fr

environmental radioactivity (BSc), environmental radioactivity, radioanalytical chemistry (MSc, 0.5-1 credits)

BSc,
MSc

GERMANY

Dedicated NRC programme(s)

RUPRECHT-KARL UNIVERSITY OF HEIDELBERG in collaboration with Karlsruhe Institute of Technology (KIT)
Faculty of Chemistry and Geoscience, Department of Physical Chemistry
<http://www.uni-heidelberg.de/fakultaeten/chemgeo/pci/>
Web pages <http://www.uni-heidelberg.de/>
Tel. 07247/824469
Fax. 07247/823927
Postal address Im Neuenheimer Feld 253, 69120 Heidelberg
Contact person: Prof. Petra Panak petra.panak@kit.edu

1) BSc in chemistry:
specialization radiochemistry =
*27 credits NRC of total 180
credits*
2) MSc in chemistry:
specialization radiochemistry =
40/120 credits

DRESDEN UNIVERSITY OF TECHNOLOGY in collaboration with
Forschungszentrum Dresden-Rossendorf
Faculty of Science, Dept. Chemistry/Food Chemistry, Professorship
Radiochemistry
<http://www.chm.tu-dresden.de/anc2/>
Head of the Department / Group Prof. Dr. Gert Bernhard
Tel. +49 351 260-3210
Fax. +49 351 260-3553
Postal address Dresden University of Technology, Faculty of Science,
Dept. Chemistry/Food Chemistry, Professorship Radiochemistry
Postfach, 01062 Dresden / Germany
Contact person: Prof. Gert Bernhard
Gert.Bernhard@mailbox.tu-dresden.de

1) MSc in chemistry:
specialization (module)
radiochemistry
*for other students also
radioanalytics at BSc level (and
environmental and
radiochemistry at MSc level)

UNIVERSITY OF KÖLN in collaboration with Forschungszentrum
Jülich
Faculty of Science, Department of Chemistry, Division of Nuclear
Chemistry at the Institute of Biochemistry
http://www.uni-koeln.de/math-nat-fak/nukchem/index_e.htm
Head of the Department / Group
Prof. Dr. H. H. Coenen (at Forschungszentrum Jülich)
Dr. B. Kuczewski (at University Cologne)
Web pages <http://www.uni-koeln.de/math-nat-fak/nukchem/>
Tel. 0049-221-470-3219
Postal address Zülpicher Strasse 45/50674 Köln /Germany
Contact person: Dr. Bernhard Kuczewski
b.kuczewski@uni-koeln.de

1) BSc in chemistry:
specialization (=module)
nuclear chemistry = *25 credits
NRC of total 180 credits*
2) MSc in chemistry:
specialization (=module)
nuclear chemistry = *43 credits
NRC of total 120 credits*
* MSc courses applicable in
PhD studies

FH AACHEN-UNIVERSITY OF APPLIED SCIENCES

Speciality Chemistry and Biotechnology, Nuclear Chemistry

http://www.fh-aachen.de/nuclear_applications.html

Head of the Department / Group Prof. Dr. Ulrich W. Scherer

Web pages www.fh-aachen.de/2014.html

Tel. +49-241-600953894

Fax. +49-241-600953199

Postal address Heinrich-Mußmann-Str.1, D-52428 Jülich
, Germany

Contact person: Prof. Ulrich W. Scherer

scherer@fh-aachen.de

1) BSc in Applied Chemistry:
10-40 credits NRC of total 180 credits

2) European MSc in Nuclear
Applications = *30-90 credits*
NRC of total 120 credits

LEIBNIZ UNIVERSITY OF HANNOVER

Institute for Radiation Protection and Radioecology

Head of the Department / Group Prof. Dr. Rolf Michel (until 31.3.2010)

Web pages www.zsr.uni-hannover.de

www.irs.uni-hannover.de

www.strahlenschutzkurse.de

Tel. +49-171-644 2719

Postal address Herrenhäuser Str. 2
D-30419 Hannover

Contact person: Prof. Rolf Michel

michel@irs.uni-hannover.de

1) MSc in analytical chemistry:
including radioanalytics,
radioecology and radiation
safety = *22 credits*

2) MSc in mineralogy: module
in radioanalytics and radiation
safety = *12 credits*

FREIE UNIVERSITÄT BERLIN

Institute of Chemistry and Biochemistry, Inorganic chemistry,
Radiochemistry group

Head of the Department / Group Prof. Ulrich Abram

Web pages <http://www.bcp.fu-berlin.de/chemie/en/ac/agabram/index.html>

Tel. #49 30 838 54002

Fax. #49 30 838 52676

Postal address Fabeckstrasse 34-36
D-14195 Berlin, Germany

Contact person: Prof. Ulrich Abram

abram@chemie.fu-berlin.de

1) MSc in chemistry:
specialization (*17 credits*
courses+diploma work)
radiochemistry
* basic radiochemistry also at
BSc level

NRC course(s) under other educational programme(s) *Level*

KARLSRUHE INSTITUTE OF TECHNOLOGY

Fakultät für Chemie und Biowissenschaften

Institute for Nuclear Waste Disposal (INE) <http://www.kit.edu/kit/english/>

Contact person: Prof. Horst Geckeis

horst.geckeis@kit.edu

nuclear waste management,
radioanalytics

JOHANNES GUTENBERG UNIVERSITY, MAINZ

Department of Chemistry, Pharmacy and Geosciences, Institute of Nuclear
Chemistry <http://www.kernchemie.uni-mainz.de/>

Head of the Department / Group Prof. Dr. Tobias Reich

Tel. +49-6131-39-25250

Fax. +49-6131-39-27250

Postal address Fritz-Strassmann-Weg 2
55122 Mainz, Germany

Contact person: Prof. Tobias Reich

tobias.reich@uni-mainz.de

nuclear chemistry (actinides from
chemistry, radiopharmaceutical 2010
chemistry at diploma level) BSc

MUNCHEN UNIVERSITY OF TECHNOLOGY

Chemistry Department, Institute for Radiochemistry www.radiochemie.de
 Head of the Department / Group Prof. Dr. Winfried Petry
 Tel. +49-89-28912202
 Fax. +49-89-28912204
 Postal address Walther-Meissner-Str. 3
 85748 Garching, Bayern, GERMANY
 Contact person: Prof. Winfried Petry
Winfried.Petry@frm2.tum.de

basic radiochemistry, special aspects of radiochemistry, radiochemistry and radiopharmacy = 3 credits BSc, MSc

TU CLAUSTHAL

Institute of Disposal Research
<http://www.ielf.tu-clausthal.de/en/ueber-uns/>
 Contact person: Prof. Klaus-Jürgen Röhlig
klaus.roehlig@tu-clausthal.de

radioactive and hazardous waste management; isotopic geochemistry (under *MSc in Radioactive and Hazardous Waste Management*) MSc

HOCHSCHULE ZITTAU/GÖRLIZ -University of Applied Sciences

Fakultät Mathematik/Naturwissenschaften
 Contact person: Prof. Dr.-Ing. Ender, Volker
v.ender@hs-zigr.de

applied nuclear and radiochemistry, power plant chemistry, fuel gas treatment – module = 10 credits MSc

GREECE

NRC course(s) under other educational programme(s) *Level*

ARISTOTLE UNIVERSITY, Thessaloniki

Faculty of Sciences, Department of Chemistry, Laboratory of Inorganic Chemistry
<http://www.chem.auth.gr/index.php?lang=en>
 Head of the Group Prof. Dr. Panagiotis Misaelides
 Web pages <http://www.chem.auth.gr>
 Tel. +30 2310 997789
 Fax. +30 2310 997753
 Postal address Laboratory of Inorganic Chemistry, Department of Chemistry, Aristotle University, GR-54124 Thessaloniki, Greece
 Contact person: Dr. Panagiotis Misaelides misailid@chem.auth.gr

radiochemistry (radiochemistry and nuclear chemistry, nuclear fuel cycle) = 4.5 credits BSc, (MSc)

UNIVERSITY OF PATRAS

School of Natural Sciences, Department of Chemistry, Radiochemistry Group
<http://www.chem.upatras.gr/index.php?lang=en>
 Tel. Head of the Department : (+302610) 997915, 997181
 Fax. (+302610) 997153 for the Head of the Department
 Postal address UNIVERSITY OF PATRAS, Department of Chemistry, Patras -26 500- GREECE
 Contact person: Symeopoulos Vasilios bds@chemistry.upatras.gr

principles and applications of nuclear chemistry = 5 credits BSc

NATIONAL TECHNICAL UNIVERSITY OF ATHENS

School of Chemical Engineering, Laboratory of General Chemistry
<http://www.chemeng.ntua.gr/>
 Head of the School Professor Emmanuel G. Koukios
 Tel. 0030 2107723096
 Fax. 0030 2107723188
 Postal address 9, Heron Polytechniou Str., Zografou Campus, Athens 15 780, Greece
 Contact person: Assoc. Professor Zaphiris G. Loizos
zloizos@chemeng.ntua.gr

radiochemistry, nuclear chemistry-nuclear technology BSc (MSc)

HUNGARY

*Dedicated NRC programme(s)***UNIVERSITY OF PANNONIA, Veszprem**

Department of Radiochemistry and Radioecology
 Head of the Department / Group Prof. Kalman Varga
 Web pages <http://radio.mk.uni-pannon.hu>
 Tel. +36 88 624 178
 Fax. +36 88 624 178
 Postal address H-8201 Veszprem, PO Box 158
 Contact person: Ass. Prof. Zoltan Nemeth
nemeth@almos.uni-pannon.hu

- 1) BSc in environmental engineering: specialization radioecology = 30/210 credits
 - 2) MSc in environmental engineering: specialization radioecology = 47/120 credits
 - 3) MSc in chemical engineering: radiochemical technology = 56/120 credits
 - 4) PhD in chemistry: specialization radiochemistry = 20/180 credits
- * for other students basics of radiation, radioecology etc. at BSc level

NRC course(s) under other educational programme(s) ***Level***

EÖTVÖS LORÁND UNIVERSITY, Budapest

Faculty of Science, Institute of chemistry, Department of Analytical Chemistry (Laboratory of Nuclear Chemistry)
<http://www.chem.elte.hu/en/main>
<http://www.chem.elte.hu/departments/magkem/eng/index.html>
 Contact person: Prof. Zoltán Homonnay homonnay@para.chem.elte.hu

nuclear chemistry, nuclear methods in materials science, nuclear techniques in structural chemistry **MSc**

DEBRECEN UNIVERSITY

a) Department of Colloid and Environmental Chemistry, Isotope and Environmental Chemistry Group
 Head of the department/group István Bányai/Noemi M. Nagy
 Web pages http://dragon.unideb.hu/~kolloid/isotope/main_i.html
 Tel. 3652512900/22263
 Fax. 3652310122
 Postal address Egyetem square 1. / Debrecen / Hungary, H-4010
 Contact person: Ass. Prof. Noemi M. Nagy noemi@tigris.unideb.hu

basic radiochemistry courses, radioanalytical chemistry = 8 credits **BSc, MSc**

b) Institute of Nuclear Research, Department of Environmental Physics
 Head of the Department / Group Dr. István Csige
 Web pages <http://www.atomki.hu/deat/>
 Tel. +3652509296
 Fax. +3652416181
 Postal address 4026 Debrecen Bem ter 18/c
 Contact person: Dr. István Csige csige@atomki.hu

radiopharmacy = 2 credits **MSc**

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS

Faculty of Natural Sciences, Institute of Nuclear Techniques
<http://www.reak.bme.hu/en/home.html>
 Contact person: Dr. Imre Szalóki szaloki@reak.bme.hu

radiochemistry, radiation chemistry **MSc**

ITALY

NRC course(s) under other educational programme(s) ***Level***

UNIVERSITY OF MILAN (Università degli Studi di Milano) in collaboration with Istituto Nazionale di Fisica Nucleare Sezione di Milano (INFN) and Italian Society of Chemistry

Laboratorio Acceleratori e Superconduttività Applicata Interdivisional
Group of Radiochemistry and Radiation Chemistry

<http://www.lasa.mi.infn.it/>

Head of the Group Prof. Mauro L. Bonardi

Web pages <http://www.GIR.mi.infn.it>

Tel. +39 02 503 19575 / 17257 / 19568

Fax. +39 02 503 19543 / 17695

Postal address V.le F.lli CERVI 201

I-20090 Segrate, Milano, Italy

Contact person: Prof. Mauro Bonardi

Mauro.Bonardi@mi.infn.it

basic radiochemistry, BSc,
radiopharmaceutical chemistry, MSc
environmental radioactivity =
10 credits

UNIVERSITY OF PAVIA

Faculty of Science, General Chemistry

www.unipv.eu;

<http://scienze.unipv.it/?pagina=corsi&anno=2009&lettera=R>

Head of the Department / Group Antonella PROFUMO

Tel. xx39-0382-987334

Fax. xx39-0382-528544

Postal address Viale T. Taramelli, 12 I 27100 Pavia

Contact person: Ass. Prof. Massimo Oddone massimo.oddone@unipv.it

basic radiochemistry, advanced BSc
radiochemistry = *6 credits*

UNIVERSITY OF NAPOLI

Faculty of Science, Department of Chemistry

<http://chemistry.unina.it:8080/home.html>

Contact person: Prof. Augusto De Renzi

augusto.derenzi@unina.it

chemistry of radioisotopes MSc

THE NETHERLANDS

Dedicated NRC programme(s)

DELFT UNIVERSITY OF TECHNOLOGY

Faculty of Applied Sciences, Department Radiation and Isotopes for Health

<http://www.tudelft.nl/live/pagina.jsp?id=70f9805f-de88-4790-83dc-b5b04db554a6&lang=en>

Postal address: Mekelweg 15, 2629 JB Delft

The Netherlands

Fax : +31 (0)15 278 3906

Contact person: Ass. Prof. Daniel J. DeVries

Daniel.DeVries@tudelft.nl

1) MSc in chemical
engineering: specialization
nuclear science and engineering
= *30-70 credits NRC of total
105 credits*

NORWAY

Dedicated NRC programme(s)

NORWEGIAN UNIVERSITY OF LIFE SCIENCES, ÅS

Department of Plant and Environmental Sciences, Environmental
Chemistry

<http://www.umb.no/ipm-en>

<http://www.umb.no/study-options/article/european-master-of-science-in-radioecology>

Head of the Department / Group Øystein Johnsen / Brit Salbu

Tel. +47 64965540

Fax. +47 64966007

Postal address P.O. Box 5003, NO-1432 Ås, Norway

Contact person: Ass. Prof. Lindis Skipperud

Lindis.skipperud@umb.no

1) EurMSc in radioecology = *90 credits
NRC of total 120 credits*
2) MSc in chemistry: specialization
radiochemistry = *90/120 credits*
3) PhD in chemistry: specialization
nuclear and radiochemistry = *20-60/60
credits*
* radiochemistry/radioecology also for
other students at MSc level

UNIVERSITY OF OSLO

Department of Chemistry, Centre for Accelerator Based Research and Energy Physics (SAFE), Nuclear Chemistry Group www.safe.uio.no; <http://www.kjemi.uio.no/english/>
 Head of the Department / Group D. of Chemistry head: Svein Stølen
 Nuclear Chemistry Group head: Jon Petter Omtvedt
 SAFE centre head: Jon Petter Omtvedt
 Tel. +47 228 55 446 (C. department), +47 957 83 857 (Omtvedt)
 Postal address P.O. Box 1033 – Blindern
 NO-0315 Oslo, Norway
 Contact person: Prof. Jon Petter Omtvedt
j.p.omtvedt@kjemi.uio.no

1) MSc in chemistry:
 specialization nuclear
 chemistry=80-100 credits NRC
 of total 120 credits
 2) PhD in chemistry:
 specialization nuclear
 chemistry = 40/50 (plus thesis
 130) credits
 *radioactivity and
 radiochemistry also at BSc
 level

POLAND

Dedicated NRC programme(s)

MARIA CURIE SKŁODOWSKA UNIVERSITY, LUBLIN

Faculty of Chemistry, Department of Radiochemistry and Chemistry of Colloids <http://radiochemistry.umcs.lublin.pl/home/ZRiChK.htm>
 Head of the Faculty prof. dr hab. Stanisław Chibowski
 Tel. +48 81 537 56 02
 Fax. +48 81 533 28 11
 Postal address. M. Skłodowskiej - Curie 3 Sq.
 20-031 Lublin, Poland
 Contact person: Academic teacher Elżbieta Grządka egrzadka@wp.pl

1) MSc in analytical chemistry:
 specialization radiochemistry
 * radiochemistry and
 radioisotopic techniques also at
 BSc level

UNIVERSITY OF GDANSK

Faculty of Chemistry, Analytics and Environmental Radiochemistry Chair
 Head of the Department / Group Prof. Bogdan Skwarzec
 Web pages <http://www.chem.univ.gda.pl/>
http://www.chem.univ.gda.pl/kars/index_en.html
 Tel. (48 58) 5235338; 5235416
 Fax. (48 58) 5235472; 5235416
 Postal address Sobieskiego 18/19
 80-952 Gdańsk, Poland
 Contact person: Prof. Bogdan Skwarzec
bosk@chem.univ.gda.pl

1) MSc in environmental
 protection: specialization
 radiochemistry
 2) MSc in chemistry:
 specialization nuclear and
 radiochemistry
 3) PhD in chemistry:
 specialization nuclear and
 radiochemistry

NRC course(s) under other educational programme(s) *Level*

UNIVERSITY OF WARSAW

Faculty of Chemistry, Division of Physics and Radiochemistry, Laboratory of Radiochemistry
 Head of the Department / Group Prof. Paweł Kulesza
 Web pages www.chem.uw.edu.pl/index_en.php
 Tel. +48 22 822 02 11
 Fax. + 48 22 822 59 96
 Postal address Pasteura 1
 02-093 Warsaw, POLAND
 Contact person: Prof. Jerzy SZYDŁOWSKI jszydlow@chem.uw.edu.pl

nuclear chemistry, nuclear
 energy and radioactivity,
 radiopharmaceutical synthesis
 and its application in medicine,
 isotope effects = 20 credits

BSc,
 MSc

NICOLAUS COPERNICUS UNIVERSITY, Torun

Faculty of Chemistry, Department of Nuclear Chemistry
<http://www.chem.umk.pl/Faculty-of-Chemistry.html>
<http://www.chem.uni.torun.pl/RAD.html>
 Contact person: Prof. Alexandre G. Chostenko chost@chem.uni.torun.pl

nuclear chemistry

BSc,
 MSc

INSTITUTE OF NUCLEAR CHEMISTRY AND TECHNOLOGY, Warsaw

a) Centre for Radiochemistry and Nuclear Chemistry
 b) Laboratory of Nuclear Analytical Methods
 Head of the Department / Groups a) Jerzy Narbutt; b) Halina Polkowska-Motrenko
 Web pages www.ichtj.waw.pl
 Tel. a) +4822 504 1126; b) +4822 504 1078
 Fax. +4822 811 1532
 Postal address Dorodna str. 16 / 03-195 Warszawa / Poland
 Contact person: Jerzy Narbutt j.narbutt@ichtj.waw.pl

coordination chemistry, nuclear chemistry MSc, PhD

SLOVAKIA

Dedicated NRC programme(s)

COMENIUS UNIVERSITY, BRATISLAVA

Faculty of Natural Sciences, Department of Nuclear Chemistry
<http://www.fns.uniba.sk/index.php?id=2389>
 Head of the Department / Group Assoc. Prof. L. Matel, PhD.
 Web pages <http://www.fns.uniba.sk/>
 Tel. +421 60296397
 Fax. +421 60296397
 Postal address Mlynska dolina / 84215 Bratislava
 Contact person: Prof. Pavol Rajec rajec@fns.uniba.sk

1) MSc in chemistry: specialization Nuclear Chemistry and Radioecology = 100/120 credits
 2) PhD in chemistry: specialization Nuclear Chemistry = 218/240 credits
 * basic radiochemistry (I-II) also at BSc level

NRC course(s) under other educational programme(s) *Level*

TECHNICAL UNIVERSITY OF ZVOLEN

Faculty of Ecology and Environmental Sciences, Department of Environmental Engineering <http://www.tuzvo.sk/en>
 Contact person: Prof. Juraj Ladomerský ladomer@vslld.tuzvo.sk

radioecology, nuclear analytical methods BSc, MSc

SLOVENIA

NRC course(s) under other educational programme(s) *Level*

JOŽEF STEFAN INTERNATIONAL POSTGRADUATE SCHOOL, LJUBLJANA (in collaboration with J Stefan Institute, University of Nova Gorica, University of Ljubljana, University of Primorska)

<http://www.mps.si/splet/index.asp?lang=eng>
 J Stefan Institute, Group for Radioecology <http://en.environment.si/section-structure/group-for-radioecology/>
 Contact person: Dr. Borut Smodiš borut.smodis@ijs.si

radioecology, radioactive and nuclear methods for the study of processes MSc, PhD

SPAIN

NRC course(s) under other educational programme(s) *Level*

UNIVERSITY OF BARCELONA (Universitat de Barcelona)

Faculty of Physics and Chemistry, Department of Analytical Chemistry
http://www.ub.es/dqa/eng/index_eng.html
 Contact person: Prof. Montse Llaurado montse.llaurado@ub.edu

radiochemical techniques MSc

UNIVERSITY OF GRANADA (Universidad de Granada)

Faculty of Science, Department of Inorganic Chemistry
<http://qiserver.ugr.es/assignaturas.html>
 Contact person: Prof. María Domingo García
mdomingo@ugr.es

radiochemistry

MSc

SWEDEN

Dedicated NRC programme(s)

CHALMERS UNIVERSITY OF TECHNOLOGY, Gothenburg

Department of Chemical and Biological Engineering, Nuclear Chemistry
<http://www.chalmers.se/chem/EN/divisions/nuclear-chemistry>
 Head of the Department / Group Prof. Christian Ekberg
 Fax. +46(0)31-772 29 31
 Postal address Kemivägen 10
 412 96 Göteborg
 Sweden
 Contact person: Prof. Christian Ekberg che@chalmers.se

1) MSc in Nuclear Engineering: specialization Nuclear chemistry = 75/120 credits
 2) MSc in Chemistry and Biosciences: specialization Nuclear Chemistry = 45/120 credits
 3) PhD in Chemistry: specialization Nuclear Chemistry = 60/60 credits

KTH ROYAL INSTITUTE OF TECHNOLOGY, Stockholm

The School of Chemical Science and Engineering, Department of Chemistry, Nuclear Chemistry
 Head of the Department Prof. Mats Jonsson
 Web pages http://www.kth.se/che/divisions/nuchem/valkommen-till-karnkemi-pa-kth-1.16841?l=en_UK
 Tel. +46 8 790 9123
 Fax. +46 8 790 8772
 Postal address KTH Chemical Science and Engineering, Nuclear Chemistry, Royal Institute of Technology, SE-100 44 Stockholm, Sweden
 Contact person: Prof. Mats Jonsson matsj@kth.se

1) MSc in Chemical engineering or [Molecular Science and Engineering](#): “specialization” Nuclear chemistry = 52,5/120 credits
 2) PhD in Chemistry: specialization Nuclear Chemistry

UPPSALA UNIVERSITY (in collaboration with Uppsala Imanet AB, GE Healthcare, AstraZeneca AB and Affibody AB)
<http://www.uu.se/en/node605?pKod=MMN2M&lasar=10%2F11>
 Rudberg Laboratory
 Contact person: Assoc. Prof. Bo Stenerlöw bo.stenerlow@bms.uu.se

1) MSc in Medical Nuclide Techniques: 2nd year focus on radiochemistry

SWITZERLAND

NRC course(s) under other educational programme(s) Level

UNIVERSITY OF BERN in collaboration with Paul Scherrer Institute

a) Department of Chemistry and Biochemistry, Radiochemistry Group
http://www.dcb.unibe.ch/content/index_eng.html
 b) Paul Scherrer Institut, Department Biology and Chemistry
<http://lch.web.psi.ch/webcontent/Laboratory/organigram.html>
 Head of the Department / Group Prof. Dr. Andreas Türler
 Web pages <http://lch.web.psi.ch/>
 Tel. +41 56 310 2401
 Fax. +41 56 310 44 35
 Postal address CH-5232 Villigen PSI

nuclear and radiochemistry courses, seminar on radio- and environmental chemistry > 20 credits
 BSc,
 MSc,
 PhD

Contact person: Prof. Dr. Andreas Türler andreas.tuerler@psi.ch

UNIVERSITY OF ZURICH

Institute of Inorganic Chemistry <http://www.aci.uzh.ch/>
 Contact person: Prof. Roger Alberto ariel@aci.uzh.ch

radiochemistry

MSc

TECHNICAL UNIVERSITY OF ZURICH, ETHZ (Die Eidgenössische Technische Hochschule Zürich)

Swiss Federal Institute of Technology Zürich, Institute of Pharmaceutical Sciences, The Center of Radiopharmaceutical Sciences (in collaboration with Paul Scherrer Institute and University Hospital Zürich)
<http://zrw.web.psi.ch/>
 Contact person: Prof. Roger Schibli roger.schibli@psi.ch

radiopharmaceutical chemistry MSc
 (also as a module under
*European specialization
 certificate in radiopharmacy*)

TURKEY

EGE UNIVERSITY, Izmir

a) Faculty of Science, Department of Chemistry, Division of Nuclear Chemistry
 Web pages
<http://sci.ege.edu.tr/~kimya/content.php?content.39>
 Tel. 0 232 311 2351
 Fax. 0 232 388 8264
 Contact person: Prof. Turan Ünak turan.unak@ege.edu.tr
http://fen.ege.edu.tr/kimya/turan-unak_476.ege

*NRC course(s) under other
 educational programme(s)* *Level*

nuclear chemistry courses, BSc,
 radiochemistry/radiation MSc,
 chemistry and its applications, PhD
 specific topics in NC/field
 courses

b) Institute of Nuclear Sciences
<http://nbe.ege.edu.tr/icerik.php?menu=doktora>
http://nbe.ege.edu.tr/icerik.php?menu=yuksekk_lisans
 in English: <http://nbe.ege.edu.tr/en/>

MIDDLE EAST TECHNICAL UNIVERSITY (METU), Ankara

Chemistry Department
<http://curie.chem.metu.edu.tr/>
 Contact person: Prof. İlker Özkan ilker@metu.edu.tr

nuclear analytical techniques, BSc,
 radiochemistry laboratory MSc
 nuclear (and radiation) (PhD)
 chemistry

BILKENT UNIVERSITY, Ankara

Science Faculty, Department of Chemistry
<http://www.fen.bilkent.edu.tr/~cvchem/>
 Contact person: Prof. Hasan Erten erten@fen.bilkent.edu.tr

nuclear chemistry BSc

UK

Dedicated NRC programme(s)

UNIVERSITY OF LOUGHBOROUGH

Department of Chemistry, Environmental Radiochemistry Group
 Head of the Department / Group Professor Peter Warwick
 Web pages <http://www.lboro.ac.uk/departments/cm/>
 Tel. ++44 (0)1509 2222550
 Fax. ++44 (0)1509 223925
 Postal address Department of Chemistry, Loughborough University,
 Loughborough, Leicestershire LE11 3TU
 Contact person: Prof. Peter Warwick p.warwick@lboro.ac.uk

1) BSc/MChem in Chemical Sciences:
 part radiochemistry
 2) MSc in Chemical Sciences: part
 radiochemistry

KING'S COLLEGE LONDON in collaboration with Cancer Research UK, GE Healthcare, Tyco, Siemens Medical, Imaging Equipment Ltd and the Engineering and Physical Sciences Research Council
<http://www.kcl.ac.uk> School of Medicine
 contact person: Prof. Phil Blower philip.blower@kcl.ac.uk

1) MSc in Radiopharmaceutics & PET
 Radiochemistry = 90 credits

*NRC course(s) under other
 educational programme(s)* *Level*

UNIVERSITY OF MANCHESTER in collaboration with University of Sheffield

a) School of Chemistry

b) NUCLEAR FIRST DOCTORAL TRAINING CENTRE

Head of the Department / Group Christopher Whitehead/

Francis Livens/Nicholas Bryan

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nuclear and radiochemistry,
broad variety of NRC courses
under doctoral training
programme

BSc
PhD